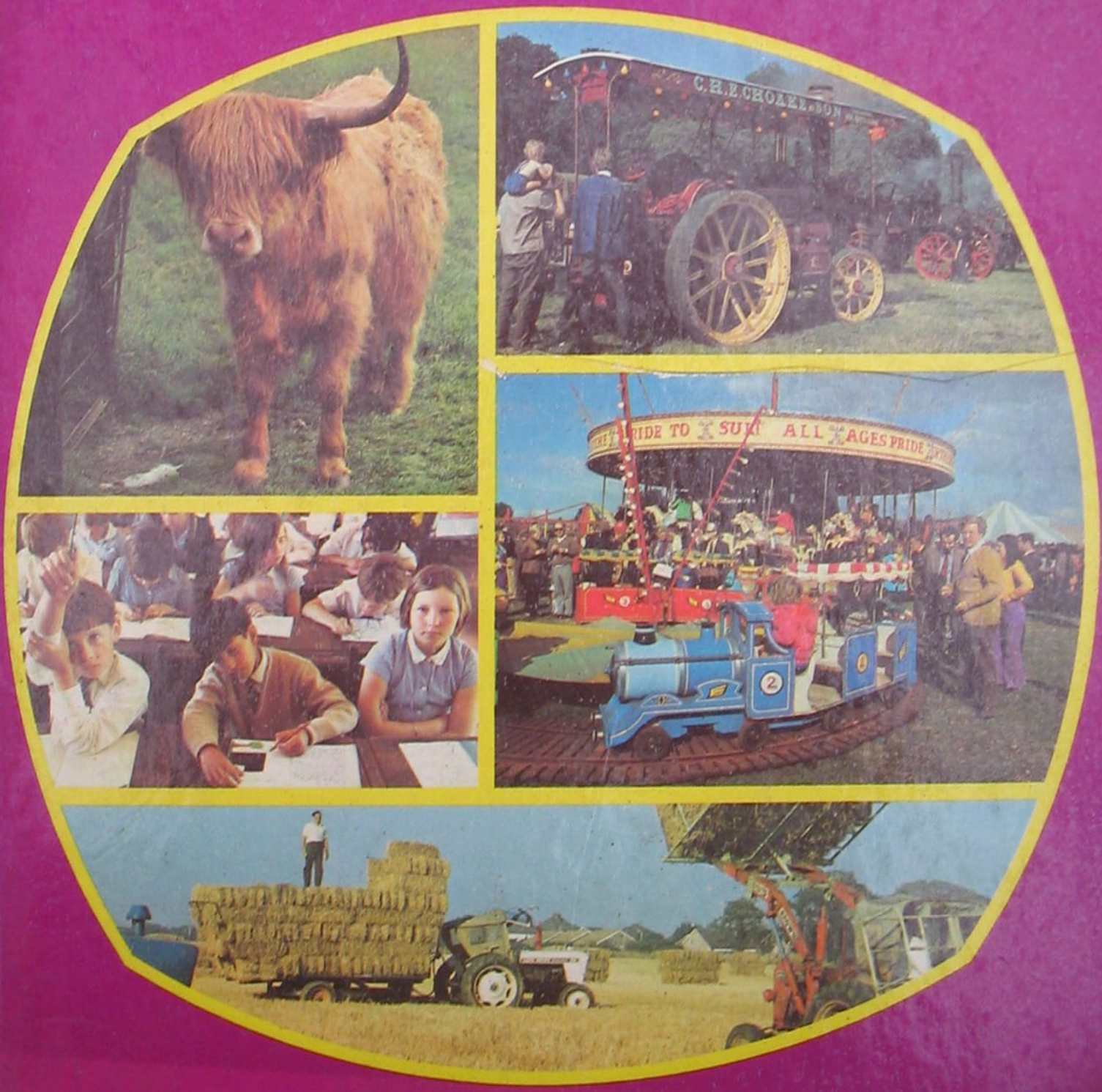
New Junior Encyclopedia

Vol 6 ear fib



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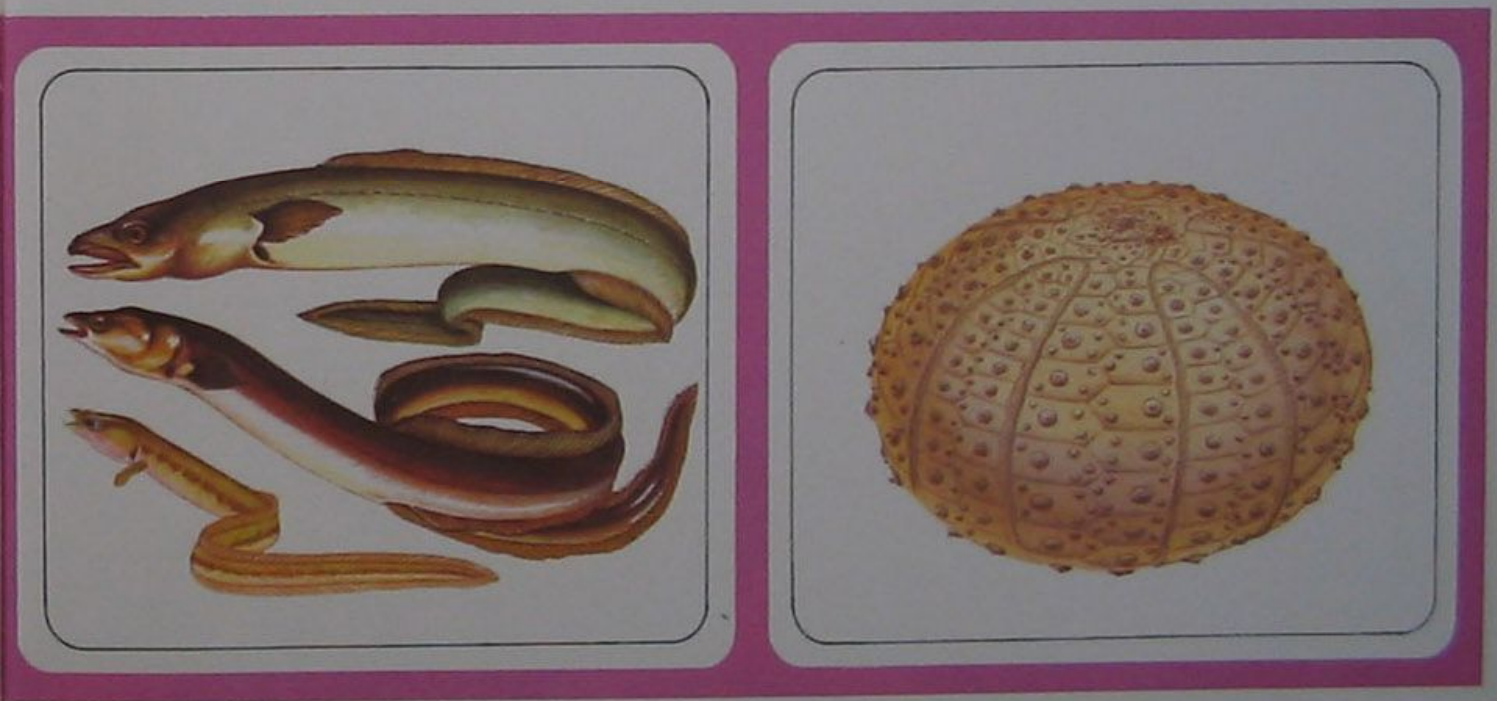

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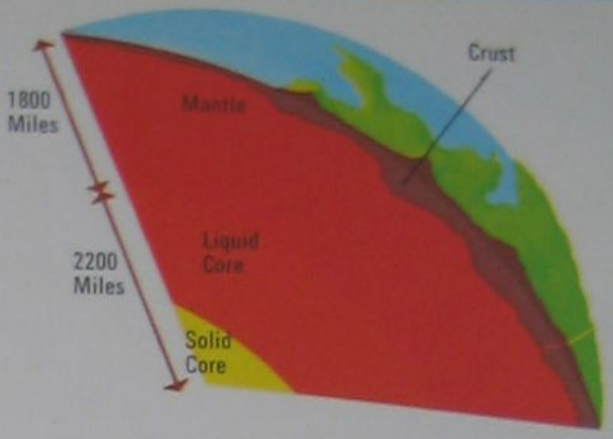
The Nile delta, Egypt, seen
from an American spacecraft

Earth is a planet in the Solar System that revolves round the Sun. Most theories about the origin of the Universe suggest that the great *galaxies,* or clusters of stars, which abound in space are formed by the coming together of a great deal of dust and gas (mostly hydrogen), which slowly condenses into a vast, rotating system of stars. Within each galaxy there are millions of stars, and our own Sun is just an average star. The Sun has acquired a family of planets in orbit around it. Our Earth is one of these planets.

Some scientists explain the origin of these planetary systems, which must also exist for other stars, by suggesting that both the Sun and its planets condensed at the same time from part of the material forming the galaxy Other scientists believe that the Sun was formed first, and that a close approach by another star drew from it a large thread, or filament, of material. This then separated into a number of pieces revolving around the Sun and condensed to form the individual planets.

The Earth is, roughly speaking, a ball or sphere about 8,000 miles in diameter. It is rocky on the outside, and is about 5½ times as heavy as a quantity of water the same size would be. Parts of its surface are very rugged, and almost three-quarters of the total surface area is covered by water.

Scientists cannot learn much about the inside of the Earth by studying the surface of it. They learn more by studying earthquake waves. When there is an earthquake, the shock may travel a long way through the Earth, and the scientists can tell from the type of shock wave and the speed at which it travels, what type of substance it is travelling through.

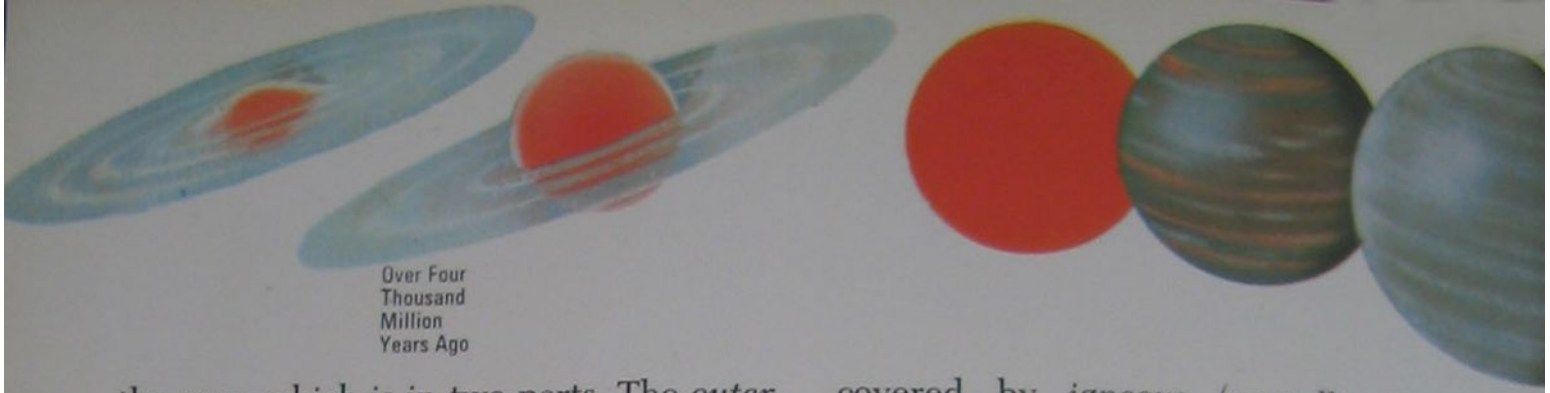


A simplified section through the Earth showing the major regions—crust, mantle and core. The crust is rarely more than 30 miles thick.

The Earth's *crust* consists of two main types of rock—*sima* and *sial.* Sima is made mainly from silicon and magnesium and sial is made mainly from silicon and aluminium. Sima is a dense rock similar to that which comes out of volcanoes, and may have been formed when most of the Earth was in a *molten* (liquid) state. Sial occurs as great 'rafts' floating in the heavier sima. Each of the 'rafts' is a continent.

Beneath the crust there is a layer, called the *mantle,* of very heavy rocks about 1,800 miles deep. The mantle surrounds

A photograph of the Earth taken from an Apollo spacecraft.



Over Four Thousand Million Years Ago

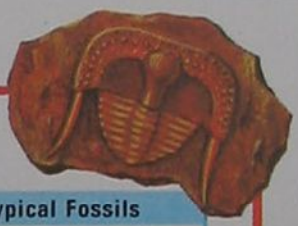
the *core*, which is in two parts. The *outer core* is liquid, and probably made from molten iron and nickel. The *inner core* is also believed to be composed of iron and nickel, but is probably solid. The diameter of the core is about 4,300 miles.

The crust is, of course, the part of the Earth we know most about. It has been bent and folded by great pressures at various times in the distant past. In some areas this earth movement has resulted in the formation of extensive mountain ranges. (See Mountains.)

Volcanic activity and earthquakes have also played a part in the formation of the Earth's crust. Parts of the crust have been covered by *igneous* (crystallized) and *sedimentary* (deposited) rocks. Some rocks have later been *metamorphosed* (changed) by heat or pressure. These so-called metamorphic rocks may in turn be covered by sedimentary rocks deposited in more recent times. (See Rocks.)

The present form of the Earth's surface has been developed over many million years. The landscapes of today show the results of great rock movement during several periods of the Earth's past. The oldest mountain ranges, such as those of Scotland and Wales, are about 400 million years old. They have been much reduced and worn away *(eroded)* during that time.

Graptolite



Trilobite

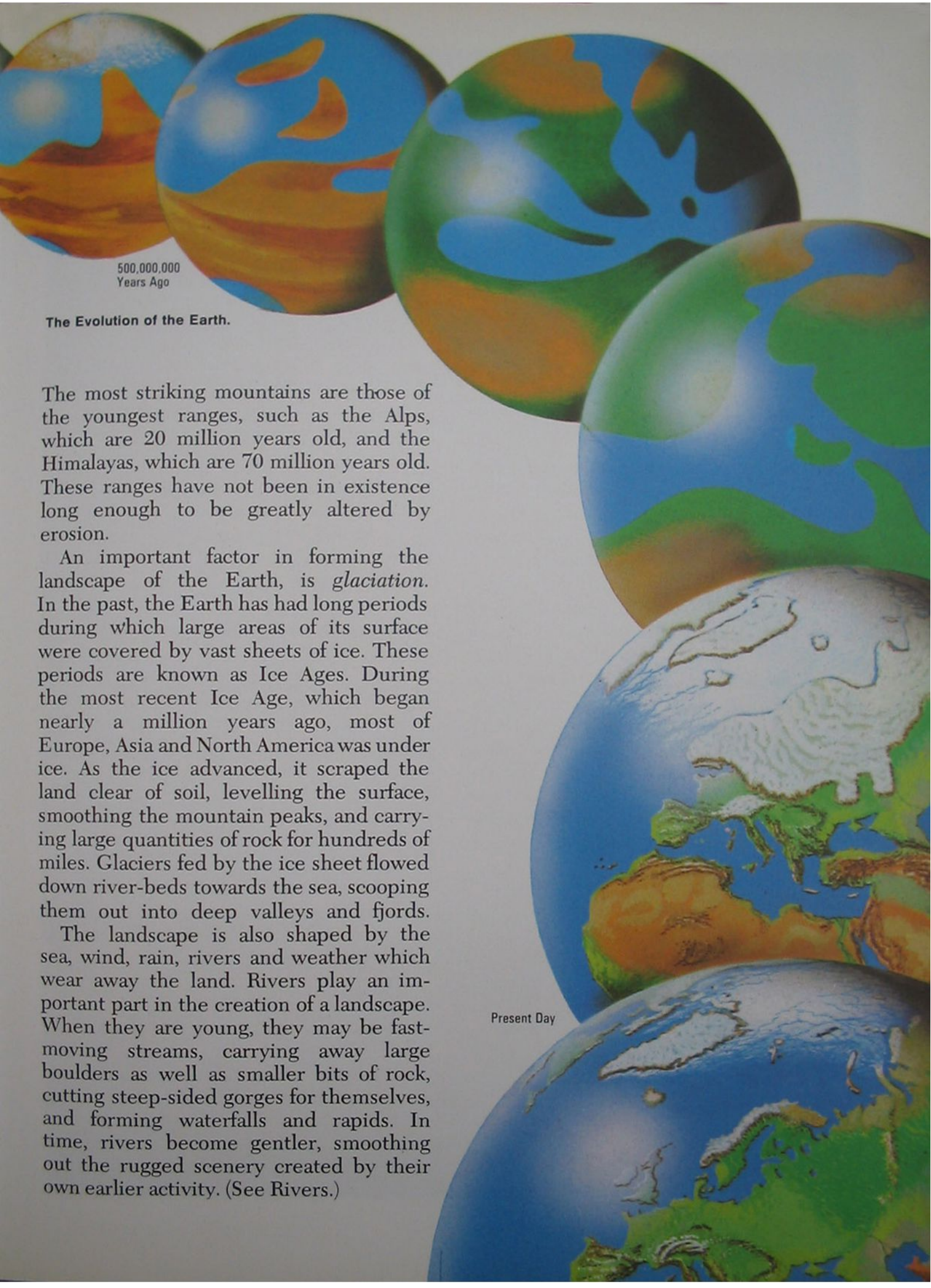
The Geological Time Scale

Era		Period	Began, Years Ago	Typical Fossils
Cenozoic Era		Quaternary	1,500,000	Man
		Tertiary	65,000,000	Mammals, Modern Invertebrates
Mesozoic Era		Cretaceous	136,000,000	Birds, Reptiles, Invertebrates
		Jurassic	195,000,000	Dinosaurs, Ammonites
		Triassic	225,000,000	Reptiles
Palaeozoic Era	Upper	Permian	280,000,000	Reptiles
		Carboniferous	345,000,000	Cephalopods, Sea Lilies, Amphibians
		Devonian	395,000,000	Early Fishes, Land Plants
	Lower	Silurian	440,000,000	Brachiopods
		Ordovician	500,000,000	Graptolites
		Cambrian	570,000,000	Trilobites
		Pre-Cambrian	Not Known	

Ammonite

Graptolite

Life forms have evolved continuously throughout the Earth's history. Thus a single species (kind) of plant or animal is confined to a certain span of time and its fossilized remains will appear only in rocks laid down during that time. From these fossils, geologists have been able to build up a record of the rocks of various ages arranged in chronological order (the geological column). Since the history of the Earth covers such a great span of time it is divided up into a number of convenient units.

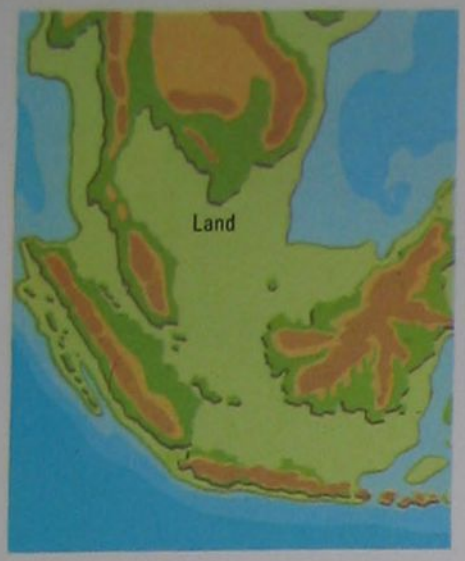


The Evolution of the Earth.

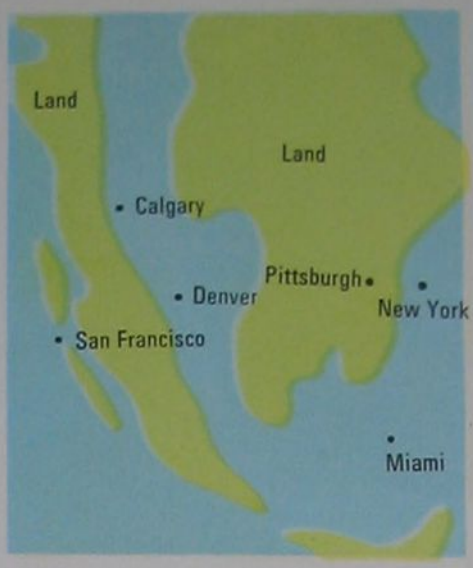
The most striking mountains are those of the youngest ranges, such as the Alps, which are 20 million years old, and the Himalayas, which are 70 million years old. These ranges have not been in existence long enough to be greatly altered by erosion.

An important factor in forming the landscape of the Earth, is *glaciation*. In the past, the Earth has had long periods during which large areas of its surface were covered by vast sheets of ice. These periods are known as Ice Ages. During the most recent Ice Age, which began nearly a million years ago, most of Europe, Asia and North America was under ice. As the ice advanced, it scraped the land clear of soil, levelling the surface, smoothing the mountain peaks, and carrying large quantities of rock for hundreds of miles. Glaciers fed by the ice sheet flowed down river-beds towards the sea, scooping them out into deep valleys and fjords.

The landscape is also shaped by the sea, wind, rain, rivers and weather which wear away the land. Rivers play an important part in the creation of a landscape. When they are young, they may be fast-moving streams, carrying away large boulders as well as smaller bits of rock, cutting steep-sided gorges for themselves, and forming waterfalls and rapids. In time, rivers become gentler, smoothing out the rugged scenery created by their own earlier activity. (See Rivers.)



A map of South-East Asia as it would appear if the land rose 600 feet (or the sea-level fell by a similar amount).



The almost unrecognisable continent pictured above is, in fact, North America as it must have appeared some 120,000,000 years ago.

A map of the British Isles as they would appear if the sea-level rose (or the land sank) 200 feet. Far greater changes have occurred before.

The study of the Earth's surface features is called *geomorphology*. This science seeks to explain how particular features were formed and to relate them to the underlying geological structure.

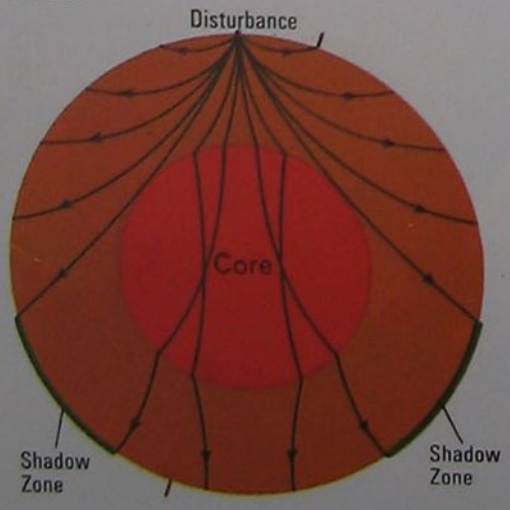
Earthquakes The Earth's crust is subject to large-scale movements, called *Earth movements*, which cause faulting and folding of the crustal rocks. In many areas of the world these movements are associated with a mountain-building process. The vibrations caused by the fracturing and movement of the crustal rocks are transmitted through the Earth, and are called *earthquakes*. Some earthquakes are caused by violent occurrences such as volcanic explosions and major landslides.

The majority of earthquakes originate from movements within the upper 50 miles of the Earth's crust. The point of origin is called the *focus*, from which the vibrations radiate in all directions. The speed at which they travel depends upon the density of the rocks through which they pass. It is greatest in dense rocks

Opposite: Earthquake damage in Kakhk, Persia; not a single building remains standing, and people search through the ruins for their possessions.

Below left: Some quake waves from a disturbance travel right through the Earth. Those which strike the Earth's core are sharply deflected because of the sudden change in density of the material through which they travel. Those that just miss the core travel on as normal. This produces a large gap in the waves reaching the surface (a shadow zone) and has helped to prove the existence of a central core of very dense material.

Below right: The distribution of the main earthquake regions corresponds closely to that of volcanic regions. Both are associated with recent mountain-building.



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such as granite and least in loose sands and gravels.

The point on the Earth's surface directly above the focus is called the *epicentre*. This is the first point to be affected by an earthquake, and suffers the greatest damage. Away from the epicentre the vibrations are less strong.

The study of earthquakes is called *seismology*. A simple scale is often used to estimate the intensity of an earthquake – the *Mercalli Scale*. At the lower end of the scale are the very feeble tremors that can be detected only by delicate instruments. At the other end are the catastrophic quakes which produce yawning crevasses in the ground and destroy everything within a large radius of the epicentre.

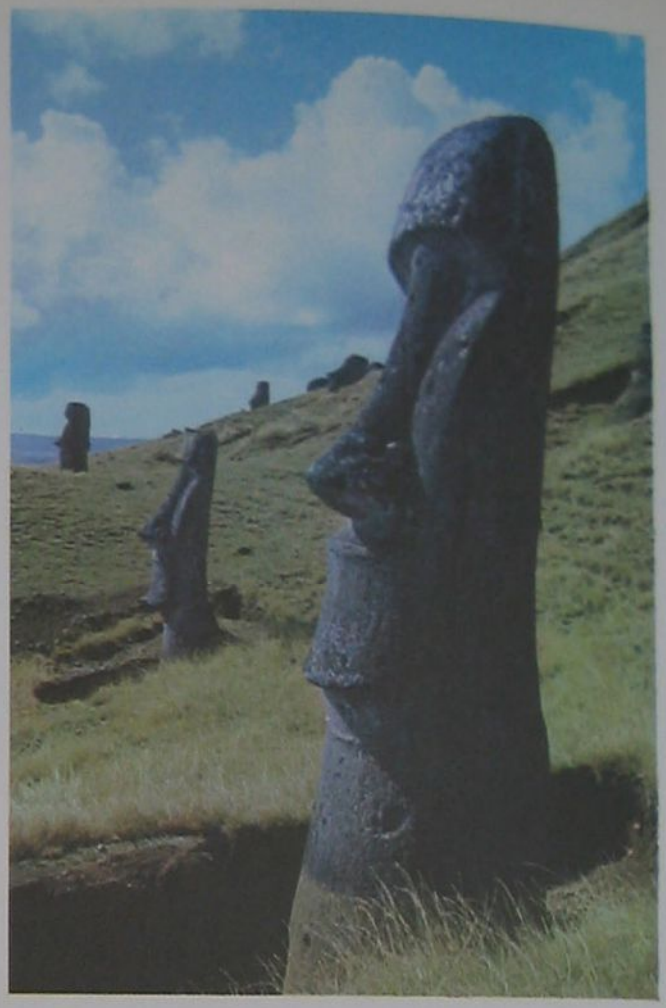
There are recording stations all over the world where all seismic activity, from major earthquakes to the faintest earth tremor, is continuously recorded. They use sensitive measuring instruments called *seismographs*.

Although earthquakes can occur anywhere, more than 80 per cent of those experienced in modern times have occurred in two major belts, both associated with mountain-formation. These are the belt around the Pacific, running northwards from Chile to Alaska, across to Japan and south to New Guinea; and the belt extending from Spain and northern Africa, through the Middle East to the East Indies.

Earwig This is an insect with a large pair of pincers at its tail end. The pincers are sometimes raised up in a threatening attitude when the insect is disturbed, but this is usually bluff as the pincers are rarely used.

An earwig is easily recognised by the pincers at its tail end.

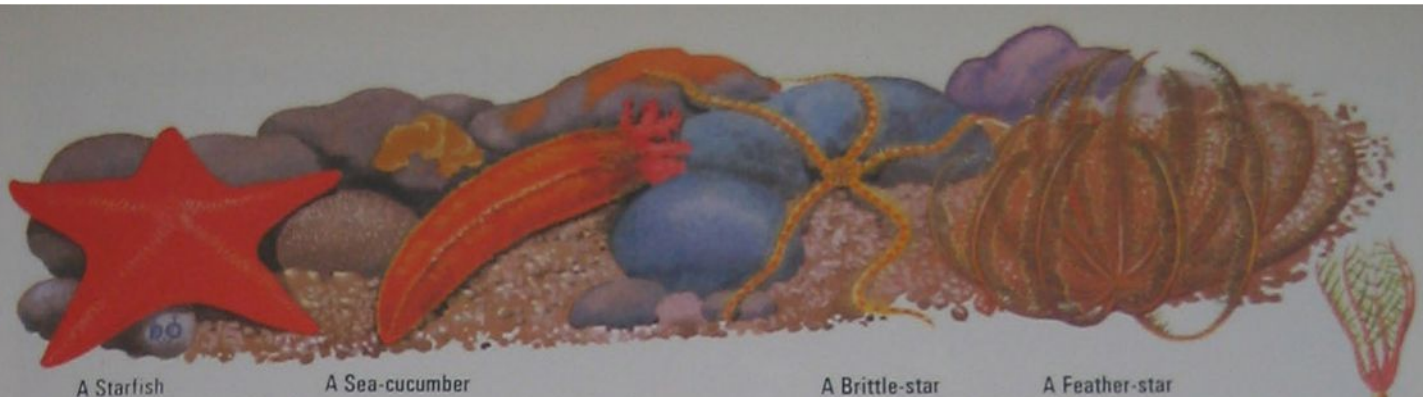
Earwigs got their name, which means 'ear beetle', because they were once thought to crawl into the ears of sleeping people. Earwigs, in fact, are harmless to man, but they do some damage by eating fruit and flowers, as well as some good by eating insect pests. Earwigs have large and delicate wings folded beneath short and leathery upper wings, but they rarely fly.



The mysterious statues of Easter Island. Some of them are over 40 feet high and weigh nearly 70 tons.

Easter Island lies in the Pacific Ocean about 2,400 miles west of Chile, which owns it, and nearly 5,000 miles east of Australia. The island is a volcanic rock covering 45 square miles. Only about 1,000 people now live there, mostly Polynesians.

Easter Island was once the home of a mysterious people who built more than 600 huge rock statues of ghostly, legless



A Starfish A Sea-cucumber A Brittle-star A Feather-star

men. Some of the statues are 40 feet high and weigh nearly 70 tons.

Unknown sculptors carved these giant statues with stone pick-axes. With no known mechanical aids, they hauled the statues up to the high ground and erected them on platforms. On the head of each statue they balanced a red stone about eight feet in diameter. The statues may have had a religious purpose. Possibly they were used in ancestor worship. Human bones have been found near them. The statue builders destroyed many small statues carved by an earlier people whom the giant-statue builders replaced and probably killed.

Polynesian adventurers sailed to the island in about 1670. They conquered it and probably killed the statue-building people. Admiral Roggeveen, a Dutch seaman, discovered Easter Island on Easter Sunday 1722, and named it. Peruvian slave traders took many people from the island in 1862. Immediately after this, smallpox further reduced the population.

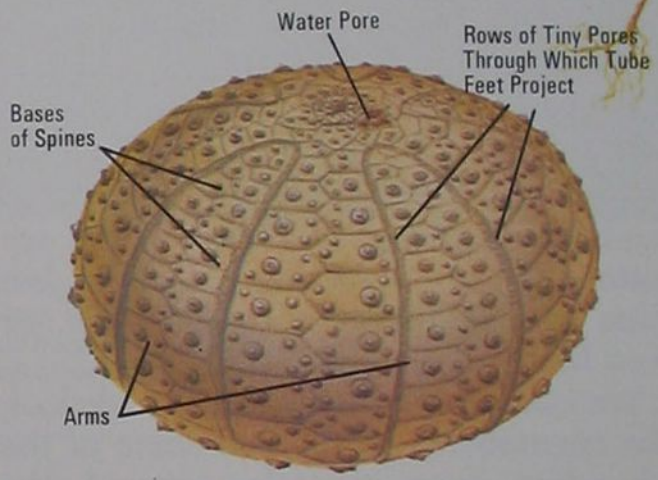
East Lothian, a county in south-eastern Scotland, was formerly called Haddingtonshire. Its county town is Haddington, and its population is 55,900.

The county is bordered by the Firth of Forth and the North Sea in the north, and Berwickshire in the south. The land rises in the south to a peak of 1,749 feet in the Lammermuir Hills. The Tyne is the only important river. Agriculture is the main industry, but there are some fisheries and coalmines. There are also a number of holiday resorts. Besides Haddington, the principal towns are North Berwick and Dunbar.

Above: Echinoderms drawn in their natural surroundings.

Right: A modern sea-lily.

Below: The test, or skeleton, of a sea-urchin. The chalky plates are all joined together in a definite pattern for the species. The rows of tube-feet pores on the 'arms' are clearly visible. They show how an urchin may be regarded as a starfish whose arms have been drawn up to meet at the top.



Echinoderms are sea animals with a rough outer covering consisting of plates of lime (chalk) embedded in the skin. The name *echinoderm* means *spiny-skinned.* There are five kinds of echinoderms: starfish, brittle-stars, sea-urchins, sea-cucumbers and sea-lilies. Most of them have bodies that show *radial* symmetry—they are symmetrical about a central point. Echinoderms are found in seas all over the world, except near the Poles. Most echinoderms have separate sexes. They breathe by absorbing oxygen from the water through their skins.

Starfish usually have five arms and are often brightly coloured. But the beautiful sunstar has twelve arms, and other starfish have up to 50 arms. Along the arms

are rows of tube feet, tiny projections with sucker discs. The starfish moves by using its tube feet to grasp objects and then pulling itself along. The centre of the starfish contains the animal's mouth and stomach. It feeds by attacking oysters, clams and other molluscs, forcing open their shells with its tube feet and extending its mouth into the molluscs' bodies.

Brittle-stars look like starfish, but have long thin arms. Brittle-stars have no suckers, although the arms are used for moving. They feed by capturing food with the arms or by pushing mud containing food particles into the mouth.

Sea-urchins have no arms. The chalky plates are all joined together and the animals are covered with many sharp spines. The mouth is on the underside and is equipped with teeth. The tube feet extend through the plates in the skin and help the animal to move about. When the animals die, the skin and spines drop off leaving a 'skeleton' of plates on the sea bottom. Most sea-urchins are round, but some are shaped like hearts, ovals, or even horse-shoes.

Sea-cucumbers are leathery and do look like cucumbers, except that some of the tube feet form tentacles around the mouth. The tentacles are used for feeding. Some species catch small animals while others use their tentacles to scoop mud into their mouths. The animals then digest any food material in it.

Sea-lilies look like plants. They may be attached to the sea-bed by a long chalky tube resembling a stalk. The mouth is surrounded by a 'flower' of feathery tentacles. Some sea-lilies have no stalk and float freely in the sea.

Echo is a sound that bounces off a distant object such as a cliff, in much the same way as a ball bounces off a wall or light is reflected off a mirror.

If you make a noise near a suitable reflecting object such as a tall building, you hear the echo a little time later. Sound travels at 1,100 feet per second. It takes a second to go to an object 550 feet away and return.

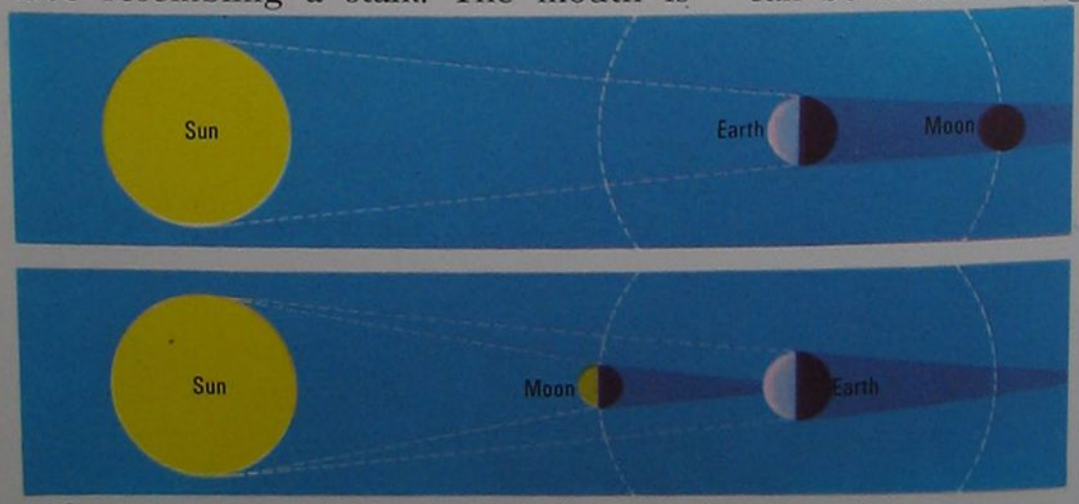
Bats avoid trees and buildings by bouncing their supersonic squeaks off them. Seamen use a device called *sonar* which measures the depth of the sea by recording echoes through the water (see Sonar). In radar, radio waves are echoed back (see Radar).

Eclipse Sometimes the Moon, in its path round the Earth, passes between the Sun and the Earth. Its shadow falls upon the Earth, blotting out the Sun's rays, and the day grows dark. This is called a *solar eclipse*.

At other times the Earth passes between the Sun and the Moon. Its shadow falls on the Moon which seems to grow dim. This is called a *lunar eclipse*.

During an eclipse the Sun or Moon is not always completely hidden. If it is, the eclipse is said to be *total*. When only part is hidden, it is *partial*.

During a solar eclipse, the Moon's disc can be seen moving gradually across the



Above left: A lunar eclipse occurs when the Moon passes into the Earth's shadow. The Earth is then between the Moon and the Sun, and the Moon is invisible from the side of the Earth facing it. Below left: A solar eclipse occurs when the Moon passes between the Earth and the Sun and blots out some of the Sun's rays.

Ecology deals among other things with the way in which animals live together. This buffalo has cattle egrets on its back; they feed on the ticks and other pests which infest the buffalo's skin.

Sun from west to east. When it is directly between the Sun and the Earth at a total eclipse, the *corona*—a beautiful circle of light around the Sun—can be seen. During a lunar eclipse, the Earth's shadow is seen to cross the bright Moon.

Astronomers can predict eclipses from their knowledge of the movements of the Sun, the Moon, and the Earth.

Ecology deals with the relationships between living organisms, both plant and animal, and between these organisms and their surroundings. It is a branch of biology, and is a modern, more scientific approach to the old study called *natural history*.

Ecology is especially important today because it helps us to become aware of the ways in which we endanger ourselves and other living creatures by tampering with nature. Ecologists have been leaders in the campaign for *conservation* (preserving and protecting natural resources) and the fight against *pollution* (fouling the Earth with waste and poisons).

The fundamental principle of ecology is that no plant or animal lives alone, completely isolated. Each takes part in countless interactions with its living neighbours and with the rocks, air and water that make up its physical environment. A plant, for example, is affected by such things as the amount of sunlight and rain it receives, the minerals present in the soil in which it grows, the bacteria that fix nitrogen in the soil, the bees that transfer its pollen, the furry or fruit-eating animals that disperse its seeds, the insects that nibble its leaves, and the viruses that cause diseases.

An animal is influenced by weather and changes in climate, the availability of plants or animals that serve as food, the number and type of its enemies, competition with rivals for a mate, and the diseases caused by *parasites* (organisms that live

off other organisms), such as parasitic fungi, bacteria and worms.

One of the most important interdependencies that ecologists study is the so-called *food chain*, the continuing line of living things feeding on one another. Because plants alone are capable of manufacturing their own food (through photosynthesis), they are always at the bottom of the food chain. Then there are animals who eat the plants (such as bees who feed on clover nectar), animals who eat the animals who eat the plants (such as mice who eat the young bees) and so on. Eventually, the last animal in the chain dies. Its body is decomposed by bacteria and fungi, and returns nutrients to the soil, in which plants grow. The relationship of feeding organisms is not in fact quite so simple as this, and it is more accurate to speak of a *food web*, a pattern of interconnections.

Because organisms do not live in isolation, ecologists almost always study a *community* of plants and animals living together, or an *ecosystem*, a community plus its environment. An aquarium is an example of an ecosystem—in this case, one that is artificially created and controlled. It has various kinds of fish, water plants and snails, and may have algae growing on the glass. It also has microscopic water creatures. The environment of this community includes the tank, with its prevailing conditions of light, temperature and oxygen, and the rocks and shells which hold the plants and behind which the fish perhaps like to hide. If well planned, the aquarium community will be stable—that is the plants and animals will be in equilibrium with each other. There will not be so many animals that they eat up all the plants without giving them a chance to produce new growth, but there will be enough animals to prevent the plants from choking up the whole tank. The oxygen balance will also be correct, for the animals will not be so numerous that they use up oxygen more quickly than it can be replaced.

The more highly industrialized a country becomes the greater risk it runs of harming the balance of nature through air pollution. By 1970 in the United States, it was reckoned that over 300 million tons of polluting chemicals were being released into the air every year. Cars and lorries were responsible for almost 50% of this total. Air pollution damages not only buildings and vegetation, but can cause diseases in Man.

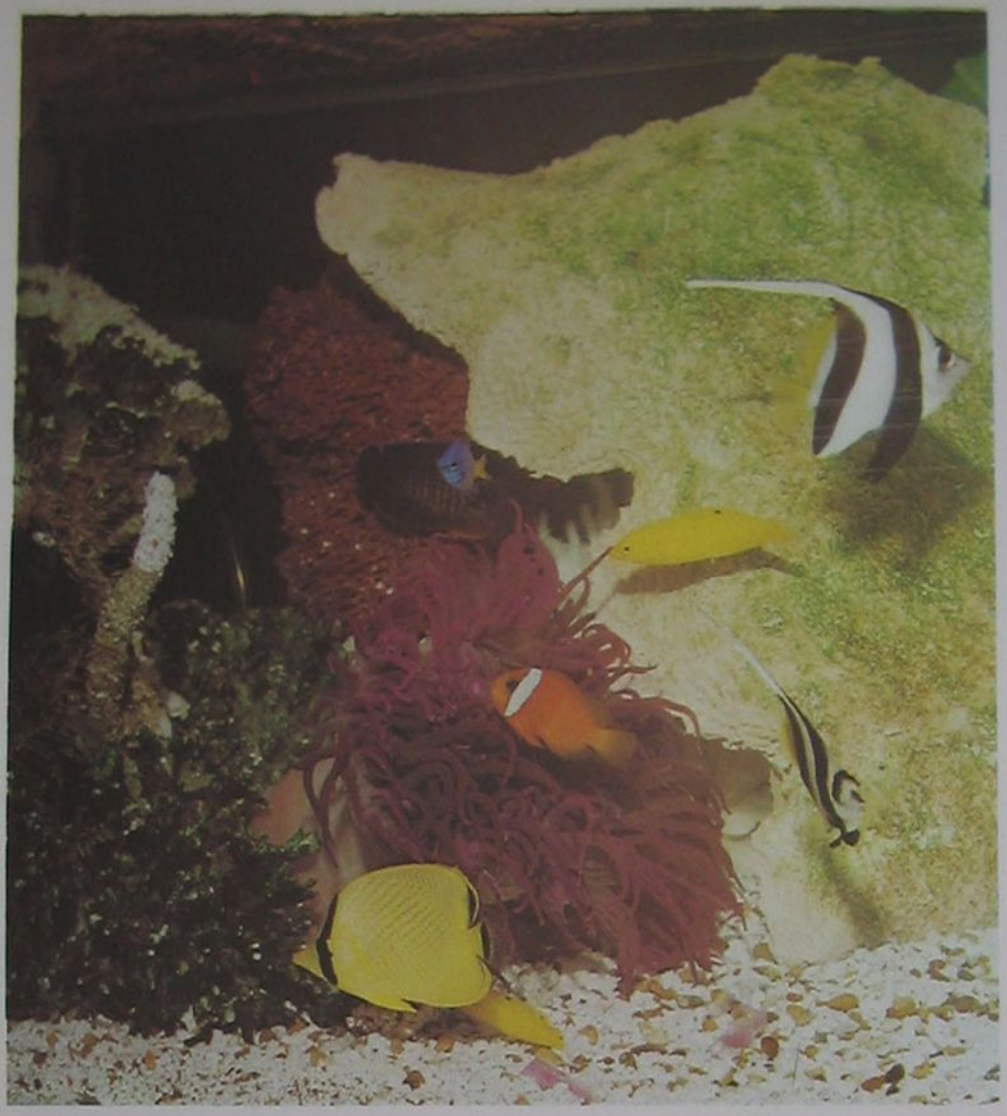
Ecologists study the various natural systems within the *biosphere* (the Earth and all the living things on it) such as the frozen Arctic and tundra regions, the temperate grasslands or plains, the tropical rain forests, the evergreen and deciduous forests, the oceans and the freshwater rivers and lakes. They study the *flora* (plants) and *fauna* (animals) of each of these systems and try to explain how each adapts to its conditions.

Ecologists use the term *balance of nature* to describe a state of equilibrium within the community, similar to that we have seen in the case of the well-run aquarium. When the balance is reached, every species has the general conditions it needs to survive. The community's population remains stable.

As long as there are no outside influences, the balance will be maintained by various self-regulating mechanisms. A simple one is availability of food. If the numbers of any particular species grow too large, there will be too little food to go around. So some animals will die, bringing the numbers down again.

Another principle of ecology is that over a period of time communities change in a more or less orderly succession. This can be illustrated by the change from a barren region to a forest. The change begins with lichens growing on the rocks. These, plus weathering, break up the rocks and allow mosses and other simple plants to get hold. When these die, they decay and create humus, the organic matter in the soil. Flowers, grasses and finally trees can grow. Additional wild-life comes to

Opposite: A ladybird eating aphids. This is a form of 'biological control'; without ladybirds aphids would multiply rapidly. Scientists worry that chemical sprays will upset such natural balances.



An aquarium is a manmade 'ecosystem' – the name ecologists give to a community of animals and plants together with their surrounding environment.

inhabit the region during each of these stages. Eventually the community reaches the stable, balanced conditions of a fully fledged forest. A community of this kind is called a *climax community,* because it is the climax or end-product of a long, slow process of change and development.

Of course, drastic changes can occur that radically alter an ecosystem and throw it off balance. Such changes may result from natural phenomena such as floods, droughts, fires or glaciers like those that covered parts of the Earth thousands of years ago. But many changes are caused by Man. When Man hunts one species of animal to extinction or introduces a new one to an area, all the other members of the community are affected. When he cuts down a forest or dumps detergents into a river, he may cause changes that are drastic and irreversible.

Unfortunately, the effects of an action may not be known for many years. Ecologists have recently discovered the serious effects of DDT and other pesticides that have been widely used since World War II to fight diseases in crops. These substances do not decompose biologically, but remain active as poisons for many years. They become lodged in the fatty tissues of animals that eat plants which have been sprayed, or, by draining from the soil into rivers, they contaminate fish. Then through the food web they reach practically every animal in the world. Scientists are concerned about dangerous levels of DDT in human beings. They also believe that several species of birds are endangered because the DDT in their bodies weakens the shells of their eggs and causes their offspring to die.

Ecological dangers can be extremely subtle. For example, some ecologists are concerned about the possible harmful

effects of supersonic aircraft. These may decompose ozone in the upper atmosphere, allowing more of the Sun's burning ultra-violet rays to reach the Earth. Even the dumping of clean water from nuclear reactors may affect river life if it is too warm.

Talking points

*Consider any animal as a unit in the food web. What does it feed on, and what feeds upon it? What would be the results if this animal were suddenly to cease to exist?

*Modern insecticides have greatly increased food production. Unfortunately, they have also upset the balance of nature. Do you think that the benefits gained from them outweigh the destruction they cause to wildlife?

*People are now becoming more aware of the environment and laws have been passed to help conserve it. Find out what they are and discuss if any more should be made.

Articles to read

All articles on wildlife; Conservation; Pollution.

Above: Market scene in Ecuador. Hats like these are characteristic of many Andes dwellers.

Left: Location map showing the position of Ecuador (black).

Facts and Figures
Area: 104,506 square miles.
Population: 6,194,000.
Capital: Quito.

Ecuador, in north-western South America, is crossed by the Equator. Its name is Spanish for *equator*. In the Pacific Ocean, about 600 miles off Ecuador's coast, lie the Galapagos Islands, which belong to Ecuador. (See Galapagos Islands.)

The Andes mountains run from north to south in Ecuador. Plains lie on both sides of the mountains. The mountains contain about 30 active volcanoes.

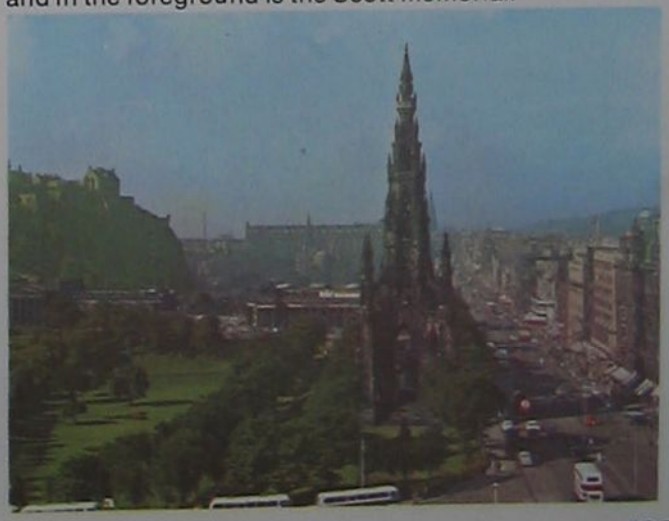
More than half of the people are American Indians who live in the cool mountain valleys, where sheep and llamas graze. Much of Ecuador lies high above sea level, and so it has a pleasantly cool climate. Most of the other people live in the coastal lowlands. They are largely of European descent or *mestizos* (mixed European and Indian). Few people live on the hot wet plains east of the Andes.

Ecuador exports more bananas than any other country, and most people work on farms or in forestry. Other important exports include cinchona trees, which are used to make the anti-malaria drug quinine, and balsa wood.

After winning freedom from Spanish rule in 1822, Ecuador became part of Greater Colombia for eight years. It then became an independent republic but, over the years, it has lost territory to its stronger neighbours. Many rebellions have occurred in the 1900's.

Edinburgh (pop. 468,000) is the capital city of Scotland. It is the county town of Midlothian and together with the port of Leith and Portobello lies on the south side of the Firth of Forth. The city is built on a series of ridged hills and is noted for the beauty of its immediate surrounds. Edinburgh is the seat of the Scottish *judicature* (administration of

Below: Looking down Princes Street, Edinburgh. On the left rises the mount topped by the castle, and in the foreground is the Scott memorial.



justice) and of a university, and has many cultural institutions. The city is dominated by its castle, with the ancient St Margaret's chapel, one of the oldest ecclesiastical structures in Scotland. The Palace of Holyrood House, originally an abbey, is the chief royal palace in Scotland.

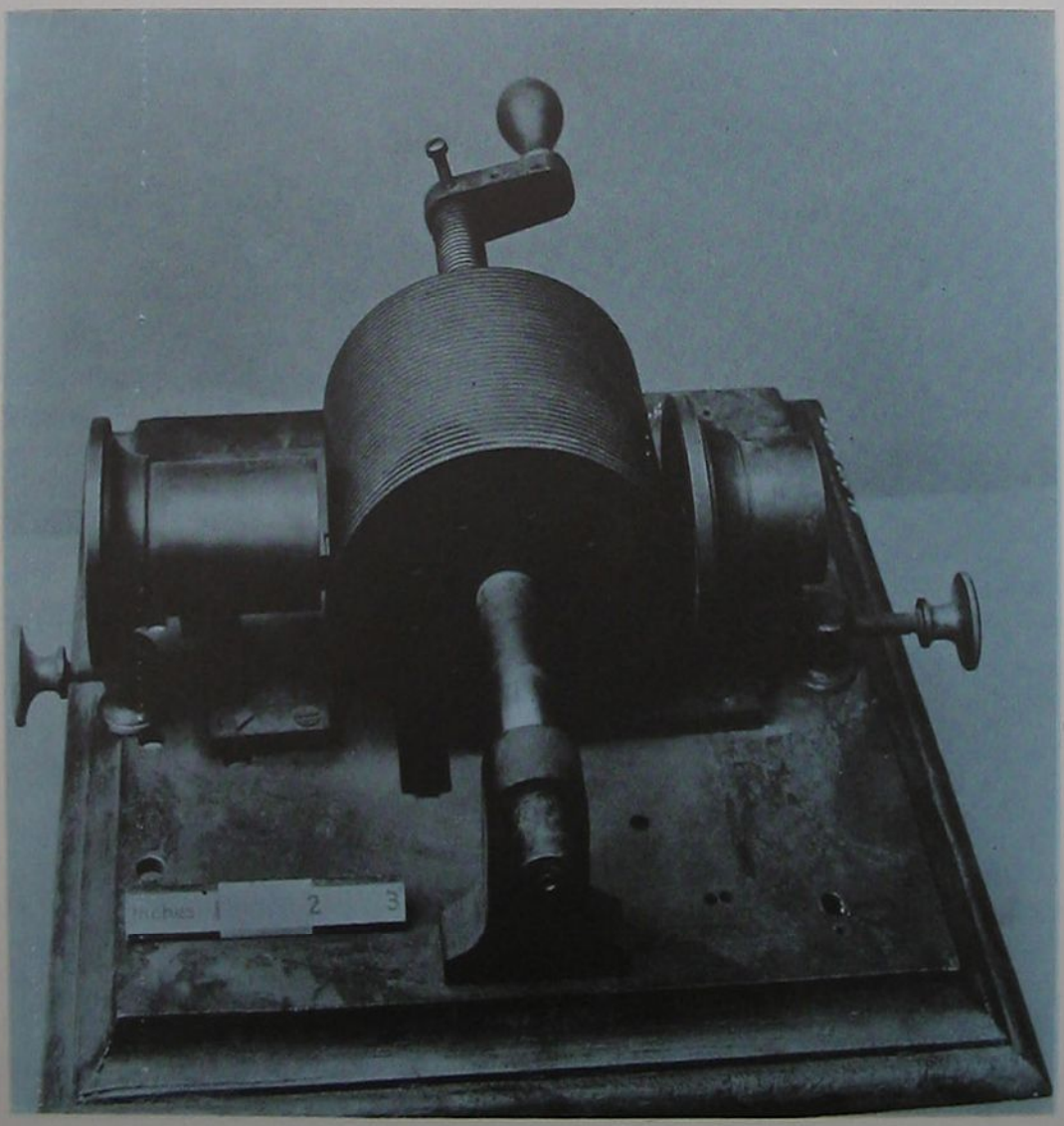
Edison, Thomas Alva (1847-1931), was an American who can justly be called the world's greatest inventor.

At the age of 12 he began selling newspapers on a train, and still found time to experiment with chemicals and print a newspaper in the luggage compartment.

Edison's first invention, when he was 16, was a gadget that sent telegraph signals automatically by being connected to a clock. He next invented an electric vote-recording machine, but politicians refused to buy it because it would interfere with their traditional counting methods.

In 1869 Edison arrived in New York and found a job in a *stock-ticker* firm. The stock-ticker was a telegraphic device used for reporting prices, in this case of gold. When one day it broke down, Edison not only repaired it but improved on it in several ways. His employers were so pleased that they offered him a large sum of money for his patents.

This money enabled Edison to set up a workshop, where he improved both the typewriter and the telephone. His most famous invention was perhaps the *phonograph*, later to be called the gramophone. This consisted of a revolving cylinder around which he wrapped a sheet of tin foil. Edison then placed a needle in the centre of a *diaphragm* (which was a stretched flat piece of material) that vibrated when hit by sound waves, causing



The first 'phonograph', invented by Thomas Edison in 1877. It was operated by a hand crank, and was the world's first machine for recording sound.

Junior school children in class. Most countries have compulsory schooling from the age of five or six. Pupils are encouraged to learn through projects and experiments as well as from books.

the needle to move on the tin foil. When Edison spoke into the diaphragm the machine repeated his words.

Undoubtedly one of Edison's most important contributions to society was an improved electric light bulb, which could be used for offices and homes. After trying hundreds of materials to find the most suitable filament, he finally used carbonized thread, which caused the bulb to glow perfectly.

The development of a motion picture camera, and later the connection of a phonograph with a camera, for talking pictures, were among other numerous achievements. Edison received many awards for his work.

Edmonton is the capital and largest city of Alberta, in western Canada. It has 435,000 inhabitants. The city is situated on the North Saskatchewan River, in the heart of the province. It stands in fertile farmlands where farmers grow cereals and rear cattle. There are also rich deposits of coal, oil and natural gas.

Edmonton is noted for its meat-packing plants, oil refineries and chemical and clothing factories. It was originally a fur-trading post and later a fort.

Education Everyone has to learn as they grow up. Sometimes we learn by ourselves without help. A baby gradually finds out how he can open and close his hands. Throughout life, too, we learn many things by copying other people. Often we need help from other people in our learning. Parents are children's first teachers. They help their children to learn how to walk and talk.

Most parents have neither the time nor sufficient knowledge to teach their children everything they need to know, so pupils go to schools (see Schools). In schools, teachers trained for their work arrange what and how the children learn. This is *formal education.*

Formal education has several stages. In the first stage children are taught to read,

write and count. They work with hands and voices, learn to use their bodies and work together. They have to begin to understand right and wrong. From this stage they go on to learn more about themselves and the world in which they live, and while they do this they use the skills which their education has given them. These two stages of education usually take place in primary or elementary schools and may continue into the secondary schools. In a third stage, at secondary schools, pupils study subjects like English, History, Geography, Social Studies, Mathematics, Science and foreign languages. These subjects add to their knowledge of the world in which they live.

As some pupils finish their schooling during this stage they need to know about the work they will do and about life as a citizen. Some schools train pupils for certain kinds of jobs. Otherwise training is given at work. Those who continue to study full-time go to a college of further education or to a university (see University). Their study is also a preparation for the work they have chosen to do. The desire to learn and understand makes many men and women want to continue to study. This they do by reading or by attending classes after work. For many people education continues long into adult life.

Talking points

*Some of the subjects that are taught in schools such as history or geography are not directly useful in adult life. However, they are considered to be an important part of education. Why do you think this is so?

*In Britain, the minimum school leaving age has been raised recently from 15 to 16 years. Discuss the advantages and disadvantages of this.

Apart from teaching us essential skills like reading, writing and mathematics, schools prepare us for a useful life in adult society. In what way do they do this?

Articles to read

Geography; History; Language; Literature; Mathematics; Schools; Universities.

Edward was the name of several English kings. Eight kings named Edward have ruled since the Norman Conquest in 1066.

Edward I (1239-1307) was the eldest son of Henry III. He ascended the throne in 1272, and tried to make one country out of England, Wales, and Scotland. He conquered Wales with the defeat of the Welsh prince, Llewellyn ap Gruffydd, in 1282. Much of the rest of his reign was devoted to warring against the Scots. In spite of his many victories over them, which earned him the nickname of 'The Hammer of the Scots', he was unable to subdue them.

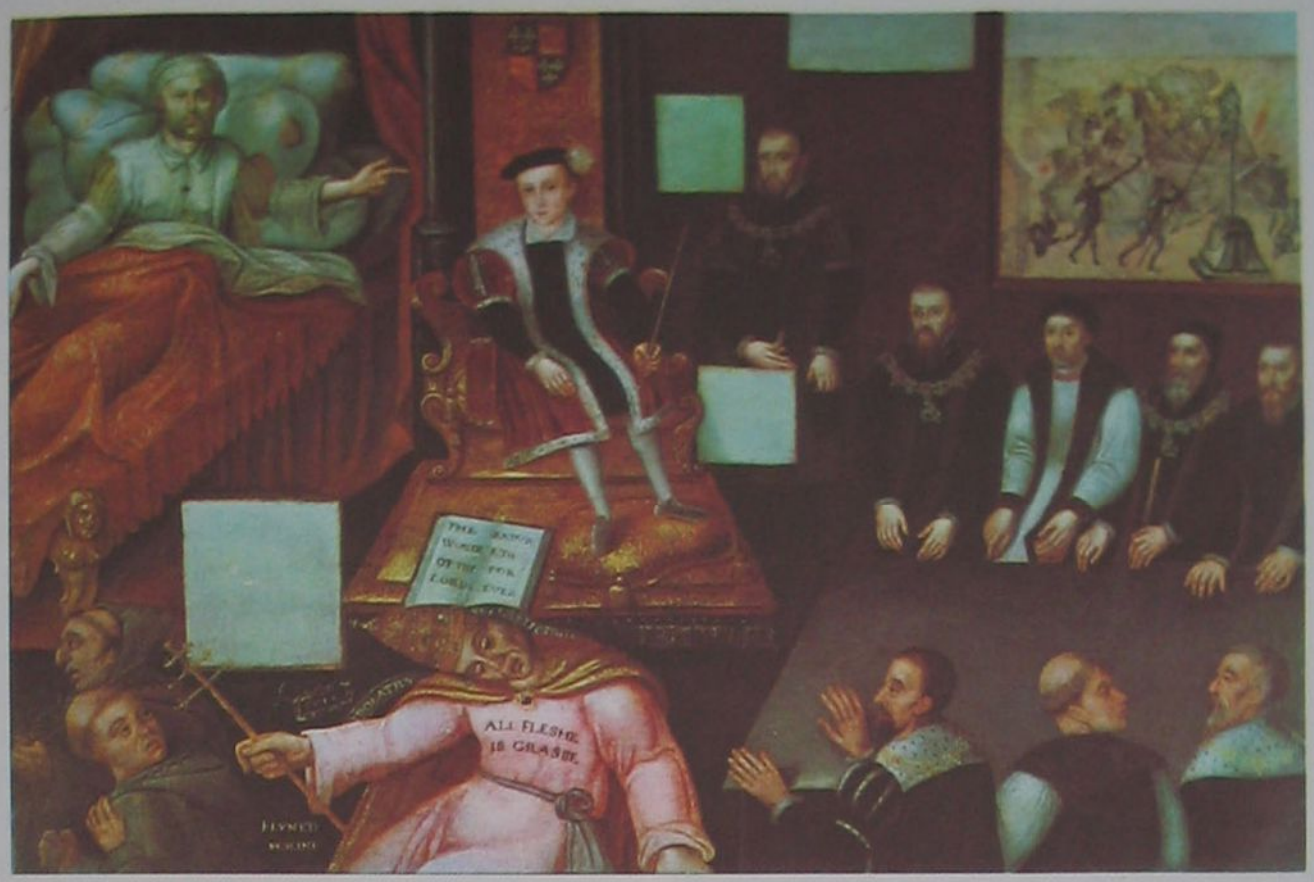
Edward was also called 'Edward the Lawgiver' because he created new laws and re-arranged existing ones. He was the first English king to insist that rich and poor were entitled to equal justice. His *Model Parliament*, which he summoned in 1295, and which for the first time represented the entire country, was the forerunner of today's Parliament.

Edward II (1284-1327) succeeded his father, Edward I, in 1307. He was the first heir apparent to be called 'Prince of Wales'. Edward was a weak, lazy king. He dismissed his father's ministers and relied instead on his personal favourites. His marriage to Isabella of France was an unhappy one. In 1314, the Scots defeated his armies at the Battle of Bannockburn, making sure of Scottish independence.

Most of Edward's reign was darkened by a bitter struggle against a group of barons under the leadership of his cousin Thomas, the Earl of Lancaster. After Edward had Lancaster executed in 1322, the struggle against him was taken up by Isabella, who fled to France and headed a fresh group of plotters. In 1327 they forced Edward to resign his throne. Later that year he was brutally murdered at Berkeley Castle, in Gloucestershire.

Edward III (1312-1377) became king of England at the age of 14, after his father, Edward II, had been deposed in 1327. His mother, Isabella, with Roger Mortimer, ruled the country until Edward overthrew them in 1330.

Edward soon successfully resumed the war with Scotland, but in 1337 he turned against France, and in that year the Hundred Years War began. Edward claimed the French throne through his mother, who was the only child of King



The dying Henry VIII points to his heir—the boy king Edward VI. Edward was greatly influenced by the strongly Protestant John Dudley, Duke of Northumberland, who controlled the Council of Regency. In the foreground is a deposed pope—symbolizing the triumph of Protestantism in England.

Philip IV of France. At first Edward won decisive battles at Crécy (1346), and, with the help of his son, the Black Prince, at Poitiers (1356). There were also naval victories at Sluys (1340) and Winchelsea (1350), and Calais was captured in 1347. Then came a temporary peace with the Treaty of Brétigny in 1360. But fighting was renewed nine years later, and finally the English managed to retain only the towns of Calais, Bordeaux and Bayonne.

Edward IV (1442-1483) was the son of Richard, Duke of York, and led the Yorkist party in the Wars of the Roses. In 1461, he marched on London, crushing the Lancastrians at the Battle of Mortimer's Cross. He was proclaimed king instead of Henry VI by a council of peers, and strengthened his position by defeating the Lancastrians at Towton in the same year.

Edward owed much of his success to the Earl of Warwick. When Warwick later changed sides and supported Henry VI, Edward was forced to flee to the Netherlands. Returning to England in 1471, he routed and killed Warwick at the Battle of Barnet, and had Henry imprisoned. The rest of Edward's reign was for the most part peaceful.

Edward V (1470-1483) became king of England at the age of 13, on the death of his father, Edward IV. His uncle, Richard, Duke of Gloucester, ruled the country as Lord Protector. But within three months of Edward's becoming king, Gloucester had him imprisoned in the Tower of London, together with his younger brother Richard. Gloucester declared the two young princes illegitimate and seized the throne for himself.

Sometime afterwards, the princes were murdered. According to tradition they were killed on Gloucester's orders, but this has never been proved.

Edward VI (1537-1553) was the only legitimate son of Henry VIII, by his third wife, Jane Seymour. He became king of

Edward VII only reigned for nine years and played little part in politics before he came to the throne. He loved smart society and was a keen sportsman.

England on the death of his father in 1547. Edward was only nine, so the country was ruled by a Council of Regency, at first controlled by his uncle, Edward Seymour, Duke of Somerset.

Somerset was later overthrown and executed, and his rival, John Dudley, Duke of Northumberland, replaced him. The boy king, a strong Protestant, was dying of tuberculosis. Northumberland, afraid that Edward's Roman Catholic half-sister Mary would succeed to the throne, persuaded him to appoint Lady Jane Grey as his heiress. But on Edward's death, Mary I did become queen.

Edward VII (1841-1910), eldest son of Queen Victoria and Prince Albert, became king of Great Britain and Ireland and emperor of India on the death of his mother in 1901.

Edward had a strict education and was excluded from all political responsibilities until middle age. He was a keen sportsman and took a lively interest in the arts and sciences. In 1860, he became the first British prince to tour Canada and the United States. His admiration and affection for the French did much to bring about a declaration of friendship between Britain and France in 1904 known as the *Entente Cordiale*. He also influenced the Anglo-Russian agreement of 1907. These and other political interventions earned him the title of 'Edward the Peacemaker'.

Edward VIII (1894-1972) was the eldest son of George V. As Prince of Wales, he served in World War I, and after the war travelled extensively. He was an immensely popular figure, and managed to combine a brilliant social life with real sympathy for poor and unemployed people.

Edward became king on the death of his father in 1936, but before he could be crowned, he announced his intention of marrying an American, Mrs Wallis Simpson. Because Mrs Simpson had been divorced, it was felt that she would not be acceptable as queen. Rather than give her up, Edward surrendered the throne in favour of his brother, George VI. The couple were married in France a year later and, as the Duke and Duchess of Windsor, settled there for the rest of Edward's life apart from his period as governor of the Bahamas from 1940 to 1945. He died in 1972, and the vast crowds that attended his lying in state showed in what affection he had been held.

Eel This is a long, thin, snake-like fish. There are more than 350 species of eels, varying in size from five inches up to nine feet. Fresh-water eels, up to three feet long, are found in the streams of western Europe and eastern North America. The adult eels leave their streams to breed at great depths near the Sargasso Sea, in the Atlantic Ocean. The parents die, and the small, transparent eel larvae drift towards the coasts. It takes them over a

year to find their way to American streams, and three years to Europe. Before they reach the coast, the larvae change into *elvers*, small eels about three inches long. The females then migrate far inland, but the males stay in rivers near the coast. The eels spend 7 to 15 years inland before migrating back to the Sargasso Sea to spawn and die.

Salt-water eels include the Moray eels of shallow tropical waters. They are often speckled with bright colours, and are fierce and dangerous. Conger eels are the largest eels—they are found in shallow waters off the coasts of western Europe.

Egg is a cell produced by a female animal or plant that develops into a new animal or plant if it is fertilized by a male cell. The egg, or *ovum*, is produced by the female sex glands or *ovaries*. The egg contains half the number of chromosomes normal for the species, and needs to join with a male *sperm* cell to complete the number and begin developing as an *embryo*. The joining of egg and sperm is known as *fertilization*.

In humans and other mammals, the egg is fertilized within the mother's body and develops there in the *womb*. In birds, the egg is also fertilized internally; it develops a hard shell but is then laid (ejected into a nest). The parent bird keeps the egg warm until the young bird hatches. Reptiles lay eggs with leathery shells. Female fish and amphibians lay unfertilized eggs in large quantities and sometimes in a jelly-like mass, and then the male deposits his sperm over them. Flowering plants produce egg cells in the *pistil* that are fertilized by pollen from the *stamen*.

Because eggs contain nutritional material meant for the young organism they are a healthy food. Most eggs we eat come from chickens. *Roe* and *caviar* (fish eggs) are considered a delicacy.

Egypt is an Arab nation in the north-eastern corner of Africa. It attracts many visitors who flock to see the pyramids, royal tombs, and other ancient monuments (see Egypt, Ancient).

Between 1958 and 1961 Egypt united with Syria to form the United Arab Republic (UAR), and Egypt kept this name when the union broke up. Egypt still wished to unite with other Arab nations, and in 1972 Egypt, Libya and Sudan announced plans to form another united Arab nation.

Barren sandy and stony deserts cover 97 per cent of Egypt. The Sinai peninsula in the north-east is the country's most mountainous region. The other deserts, the Eastern or Arabian desert and the Western or Libyan desert, are separated

Above: The conger eel, the largest of the eels, and the common European eel together with its elver.

Left: The fierce moray eel, seen eating an octopus.

Left: Location map of Egypt (black) showing its position in North Africa.
Right: For centuries Muslim women hid their faces behind a veil (yashmak). Despite Western influence a large number still do.
Below: Egypt has long been an important exporter of raw cotton. Today she processes much of the cotton herself before it is exported.

by the valley of the Nile River. Few people live in the deserts.

For thousands of years, human life in Egypt has depended on the water of the Nile. Rainfall averages about 10 inches a year near the coast, but inland it is only one inch a year.

Most Egyptians live in the narrow Nile valley or on its crowded delta. Throughout history, the Nile regularly overflowed. The floodwater spread *alluvium* or silt over the land. As a result, the Nile valley has fertile soils. Today the floodwater is controlled by huge dams, such as the High Dam at Aswan, which stores water for irrigation.

About three-quarters of the people earn their living by farming. Many farmers wear loose white trousers and white robes. Their wives wear black or coloured robes. Most Egyptians are Muslims, but about one-twelfth of the population are Coptic Christians.

Egypt's chief crop is cotton. Other important products include foodstuffs and such minerals as petroleum and manganese. One of the world's great waterways, the Suez Canal, flows through Egypt. It has been closed since the six-day war with Israel of 1967.

Egypt is a republic whose president also heads the government. The president is chosen by an elected assembly.

After the decline of Ancient Egypt, the country was invaded many times. British influence became important in the 1870's. In 1914, Britain made Egypt a protectorate. Egypt achieved independence in 1922, but British troops stayed in the country.

In the 1940's and 1950's, the Egyptians protested against the presence of British troops and in 1956, the troops left. Later that year, Israel attacked Egypt. British and French troops invaded Egypt claiming that they had to protect the Suez Canal. But they left in December, 1956. Egypt made great economic progress in

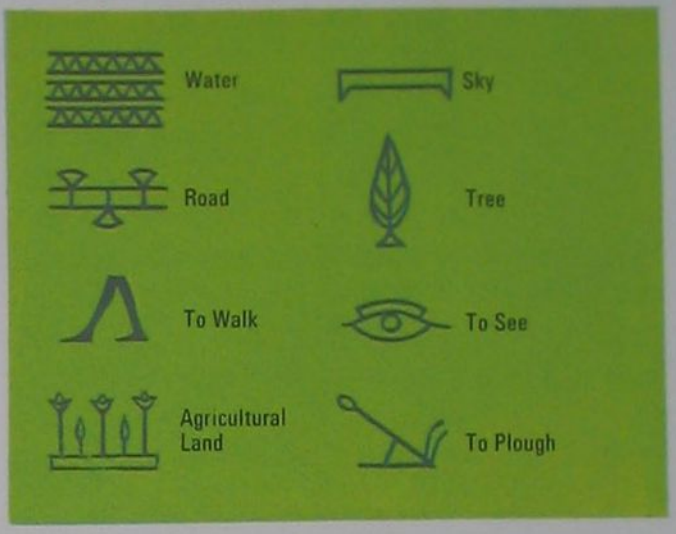
the 1960's but conflict between Egypt and Israel continued. In 1967, a six-day war took place between Israel and its Arab neighbours, including Egypt. Israel conquered much Egyptian territory.

Facts and Figures
Area: 386,101 square miles.
Population: 34,100,000.
Capital: Cairo.
Money Unit: Egyptian pound.
Exports: cotton, rice, petroleum.
Imports: fuels, manufactured goods, metals.

Egypt, Ancient Egypt was the home of one of the oldest civilizations in the world. It flourished for two thousand years, and then declined slowly for nearly another thousand years.

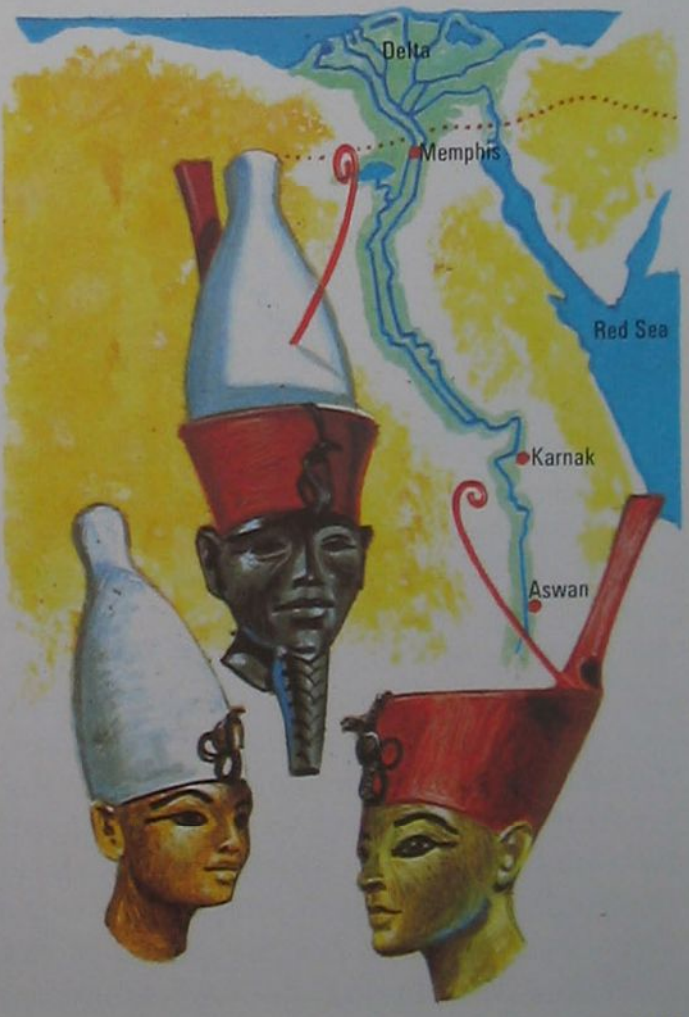
The River Nile flows for a thousand miles through desert sands to the Mediterranean Sea. Once a year floods poured down and covered the desert with silt. The Nile valley was wonderfully fertile and it became a refuge for animals and men. The valley dwellers learned how to grow barley and wheat from the Palestinians, and people settled in villages. From Asia Minor came the knowledge of how to make things of copper. Building with sun-dried bricks and pictographic writing may have been learned from Mesopotamia. Pictographs are picture writing, in which each symbol is not a letter but a picture of an object or an idea. Egyptian pictographs are called *hieroglyphs*. This mixture of an African way of life with the Bronze Age culture of the Near East produced Egyptian civilization.

The scattered villages of the Nile valley were united by Menes (or Narmer) about 3200 B.C. He was the first pharaoh of the first Dynasty, or family of rulers. The pharaoh was god and king to his subjects. The word 'pharaoh' means 'great house', and the household of the pharaoh was the government of the country. It foretold the arrival of the Nile flood and planned irrigation works, so that the flood waters enriched the largest possible area. The pharaoh's household consisted of priests and scribes (men who could write). Artists and craftsman were employed. Egyptians were masters of building and carving in stone. They made jewellery, of gold, semi-precious stones, and enamel. They also discovered a way of making a writing material (*papyrus*) from reeds.



Above: Hieroglyphs.

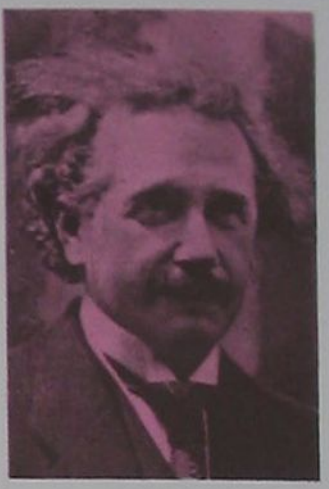
Below: When the two kingdoms of Egypt united under one pharaoh, the red crown of Lower Egypt was combined with the white crown of Upper Egypt to symbolise their new unity.



Much Egyptian art was for the dead; they were buried with all the things which they would need in the after life. The early pharaohs built great stone tombs, the pyramids. Later pharaohs were buried in tombs cut in the rock. Many people had their bodies preserved (see Mummies). The god of the dead was Osiris. The Egyptians believed that he had married his sister, Isis, and that he was killed by another god, Seth, and revived by his son, Horus. Horus was the god of sky and rain and ruled over the living. He was also a falcon or hawk god. Many Egyptian gods were half animal. Hathor was a cow-goddess. Re was the sun god of Heliopolis, the city of the sun. When Thebes became the capital of Egypt under the eleventh dynasty, Amun, the local god, became Amun-Re and king of the gods.

Four different dynasties ruled a united Egypt from *c.* 3200 to *c.* 2500 B.C. This was the Old Kingdom. The unity of Egypt was symbolised in the pharaoh's crowns: the Red Crown was for Lower Egypt, the White Crown for Upper Egypt, the upper reaches of the Nile valley. The Old Kingdom collapsed but unity was restored about 2080 B.C. by the eleventh dynasty. The Middle Kingdom lasted until *c.* 1640 B.C. Egypt was then ruled by Semitic peoples, the Hyksos, until Ahmosis, Count of Thebes, reunited the country under the eighteenth dynasty in 1570 B.C. The New Kingdom lasted until 1075 B.C.

The eighteenth dynasty had large regular armies and conquered much of Arabia. The Egyptian empire at that time was nearly lost by the Pharaoh Akhenaten who ruled in the 1340's. He tried to introduce the worship of a single god, Aten the sun, and built a new capital at Tell-el-Amarna. His successor, Tutankhamun, restored the old gods. Tutankhamun's tomb was the greatest of all finds of treasure in Egypt. Rameses II, of the nineteenth dynasty, restored some of Egypt's power. He was a great warrior king. But the power of the pharaohs was fading as new kingdoms appeared in the Middle East (see Assyrians). Persians, and later Greeks, ruled in Egypt. Some of them became pharaohs. Cleopatra (51-30 B.C.), a descendant of one of Alexander the Great's generals, ruled as pharaoh with her brother. The last native Egyptian pharaoh, Nectanebo, had died in 341 B.C.



Albert Einstein, probably the greatest mathematician to have lived.

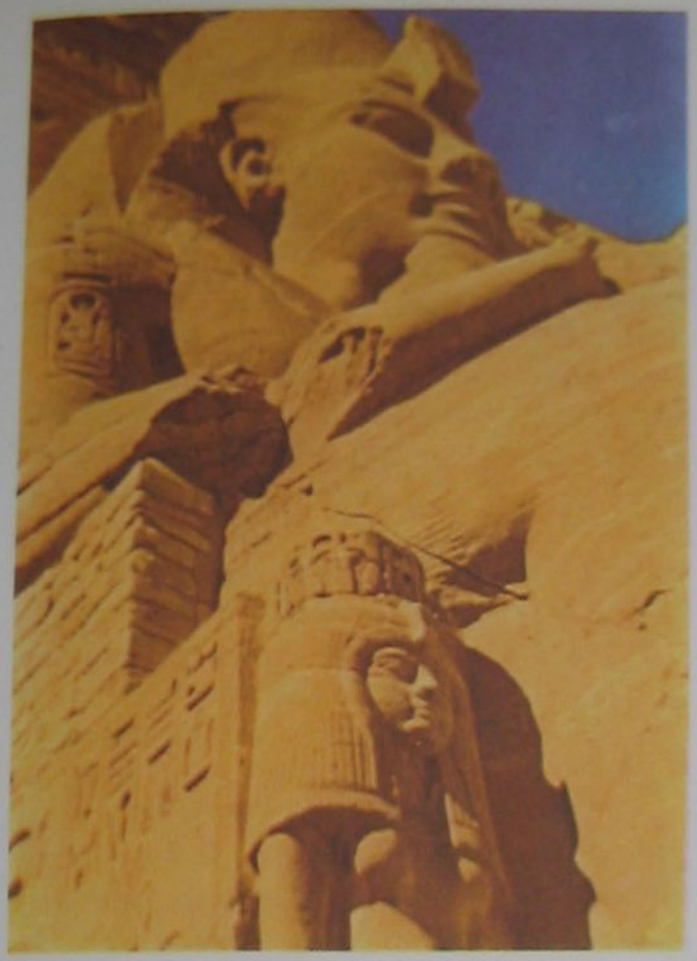
Einstein, Albert (1879-1955), ranks among the greatest scientists the world has produced. He made many outstanding contributions to science, *the theory of relativity* being one of the most famous. He was awarded the 1921 Nobel prize for physics.

In 1905 when he was still only 26, Einstein published four papers on different aspects of physics. These all became foundations for new fields of study.

The motion of particles in liquids (the Brownian motion) and the nature of light were explained in his papers. They helped prove theories of the nature of matter.

Another paper was concerned with the relation between mass and energy. Einstein put forward the now famous equation $E = mc^2$ (energy equals mass times the velocity of light squared). Einstein's work became the foundation for the atomic research which eventually led to the production of the atomic bomb.

The most important of the 1905 papers was the one dealing with the theory of relativity. This gave a new concept to the beliefs that space, time, matter, and energy were all separate from each other.



Above: Queen Nefertiti, wife of Pharaoh Akhenaten.
Right: Tutankhamun's tomb was discovered in 1922. His mummy was perfectly preserved within three coffins.
Left: Part of the huge temple built by Rameses II at Abu Simbel. The temple, weighing 11,500 tons, was recently moved piece by piece to save it from the rising waters of the lake behind the Aswan Dam.

Right: The Scarab beetle, a dung beetle, was venerated by the Ancient Egyptians, and often used as an emblem in jewellery and decoration.
Far right: The early pharaohs built great stone pyramids in which they hoped to enjoy life after death. By the Great Pyramid of Cheops (shown here) is the sphinx—a statue with the body of a lion and the head of a man. It was probably intended to guard the spirit of the dead pharaoh.

Right: Part of an 18th dynasty papyrus depicting the last judgement of the scribe Ani, by the gods Thoth and Anubis. His heart is weighed in a balance against a feather, symbolising truth. On the right the Devourer waits to eat the heart if he is proved wanting.

Einstein showed that they were in fact interchangeable.

Although born in Germany, Einstein became an American citizen in 1940, and spent the rest of his life in the United States. He was made a professor at the specially created Institute for Advanced Study in Princeton, New Jersey, and worked there till his death in 1955. (See Relativity.)

Dwight D. Eisenhower in his general's uniform. He commanded the 1944 liberation of Europe and was Republican president of the US from 1953 to 1961.

Eisenhower, Dwight David (1890-1969), one of the most famous soldiers of World War II, served as president of the United States from 1952 to 1956 and 1956 to 1961. He was a talented organizer and administrator, and because of his friendly personality was regarded with affection by people in many parts of the world.

Eisenhower was born in Texas. He graduated from West Point Military Academy in 1915. In 1942, as a general, he directed the Allied invasion of French North Africa, and in 1944 commanded the Allied forces that drove Hitler's troops out of the occupied countries of western Europe and pursued them into Germany.

Nominated for the presidency by the Republican party, Eisenhower received more votes than any previous candidate. During his terms of office, the Korean War ended, the Supreme Court outlawed racial segregation in schools and the St. Lawrence Seaway was opened.

Elections As soon as men formed bands or communities larger than a family, they found it necessary for survival to organize their efforts and choose leaders. In this way, governments and kings were established. However, as time passed and their power increased, kings gained their thrones by inheritance and governments either toppled or stayed in office according to the will of a small group of powerful people.

About 200 years ago, industrial and social developments began to force political changes. Gradually, over most of the world, governments found that they could stay in office only if they were elected or re-elected by an ever-increasing proportion of the population. By the 1970's, most advanced countries had granted the right to vote in local and general (national) elections to all citizens over either 21 or 18. Long before this time, most countries were republics under elected presidents.

In Britain, there must be a general election every five years or less, when about 630 M.Ps. (Members of Parliament) are elected to the House of Commons. Local elections are held more frequently. Every four years (in November in leap years) the *electorate* (people entitled to vote) in the United States elect their president. Every two (even-numbered) years they elect about one-third of the 100-member Senate and all members of the House of Representatives, numbering about 435. There are also frequent State and local elections.

Elections are only really genuine if the method of voting allows secrecy. Otherwise, people may vote through fear to please the existing holders of power. In countries like India, where many voters cannot read, symbols such as an elephant or a cock may be printed on ballot papers instead of names. In most countries voting is voluntary, but in some, such as Aus-

Sargent Shriver, the Democratic candidate for the post of Vice-President in the 1972 United States election, addresses a rally of supporters in Detroit. American elections are noted for the parades and rallies that go with them. Candidates will often fly by airplane from city to city to gain support from the electorate.

tralia, it is compulsory. In most countries a candidate may become an M.P. or a Senator by beating his opponents by no more than one vote. However, some countries, like the Republic of Ireland, have *proportional representation*. The electorate votes for blocks of candidates, each of whom need only secure a sufficient proportion of the votes to be elected.

Several countries held national elections at the end of 1972. In the United States, the Republican President Nixon was re-elected with a big majority. However, the Democratic Party continued to control the Senate and the House of Representatives. Willy Brandt, Social Democrat Chancellor won a clear victory in West Germany's November election. In Canada's October election, Pierre Trudeau, the Liberal prime minister, had only just managed to stay in office, but New Zealand's prime minister, John Marshall, fared even worse. In November, the electorate rejected his National government and returned a Labour government under Norman Kirk. Australia repeated the pattern in December, when the Liberal-Country coalition government of William McMahon was replaced by a Labour government for the first time in 23 years, under Gough Whitlam.

Electric fishes produce shocks of electricity to stun their prey and to defend themselves from attacks. The shocks are produced by special muscles that may take up a large part of the fish's body. Instead of producing movement, like ordinary muscles, these muscles produce electric impulses. The impulses are strong enough to paralyse prey such as fishes, frogs and crustaceans, and to keep enemies at bay.

The electric eel is the most powerful electric fish. It lives in rivers in South America, and grows to a length of about seven feet. It cannot see very well and sends out weak electric impulses to help locate objects. When attacking its prey, it produces shocks of 200 to 300 volts at a

Some of the many fishes which give electric shocks to animals that come into contact with them. The electric eel may grow to a length of 8 feet and a weight of 50 pounds.

current of a half to one ampere—enough to stun a man, though not to kill him.

Other electric fishes are not quite so powerful. The gymnotus is an eel-like fish also of South American rivers. The electric catfish lives in African rivers and the electric ray in the eastern Atlantic Ocean and the Mediterranean Sea.

Electricity An electric current is a movement, or flow, of minute particles called *electrons*. Normally, electrons are attached to an atom and circle round its central nucleus in orbits—just like artificial satellites orbiting the Earth (see Atom). Each electron has the same charge or 'packet' of electricity described as a *negative* charge. Usually the nucleus has exactly enough *positive* electrical charges to balance the negative charges on the electrons, so that the atom as a whole is neutral.

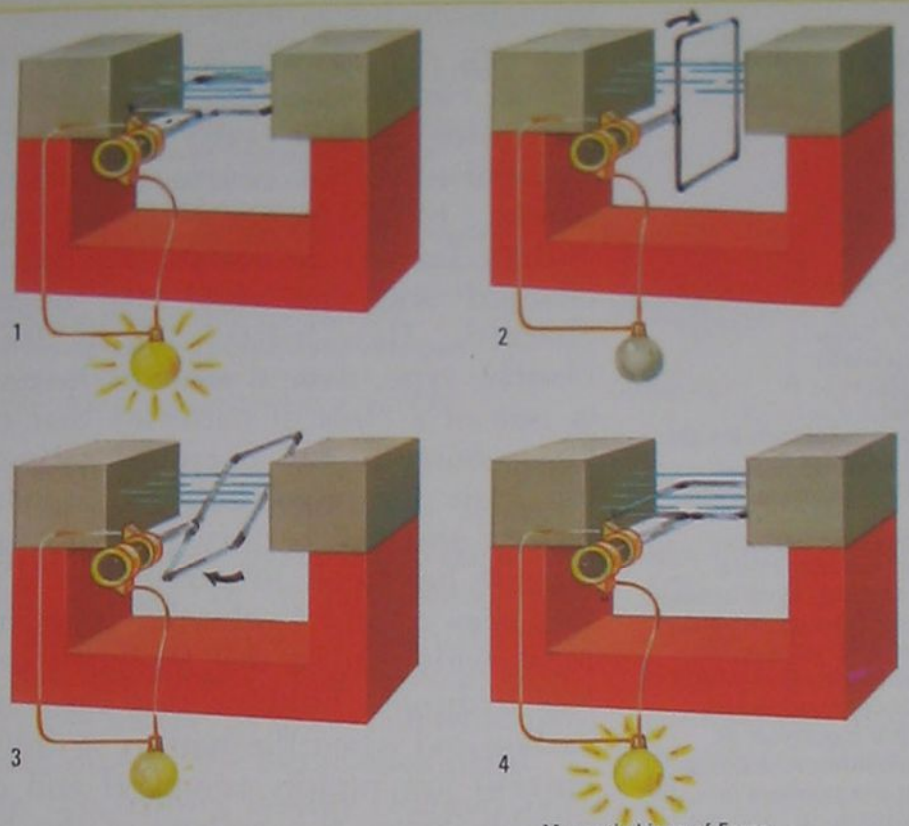
In some materials, however, a few of the electrons in each atom are only loosely held. These *free electrons* can jump from atom to atom, and it is a steady drift of free electrons that carries electricity through a wire.

Why should electrons move about between atoms? The basic law of electricity is that two similar charges (either both positive or both negative) repel each other and two opposite charges (one positive and the other negative) attract each other. Since electrons carry negative charges they are repelled by negatively charged atoms and attracted by positively charged atoms. As a result, the electrons are pushed around from atom to atom until they find one with a shortage of electrons. Alternatively, an electron may join a neutral atom if it pushes another electron out.

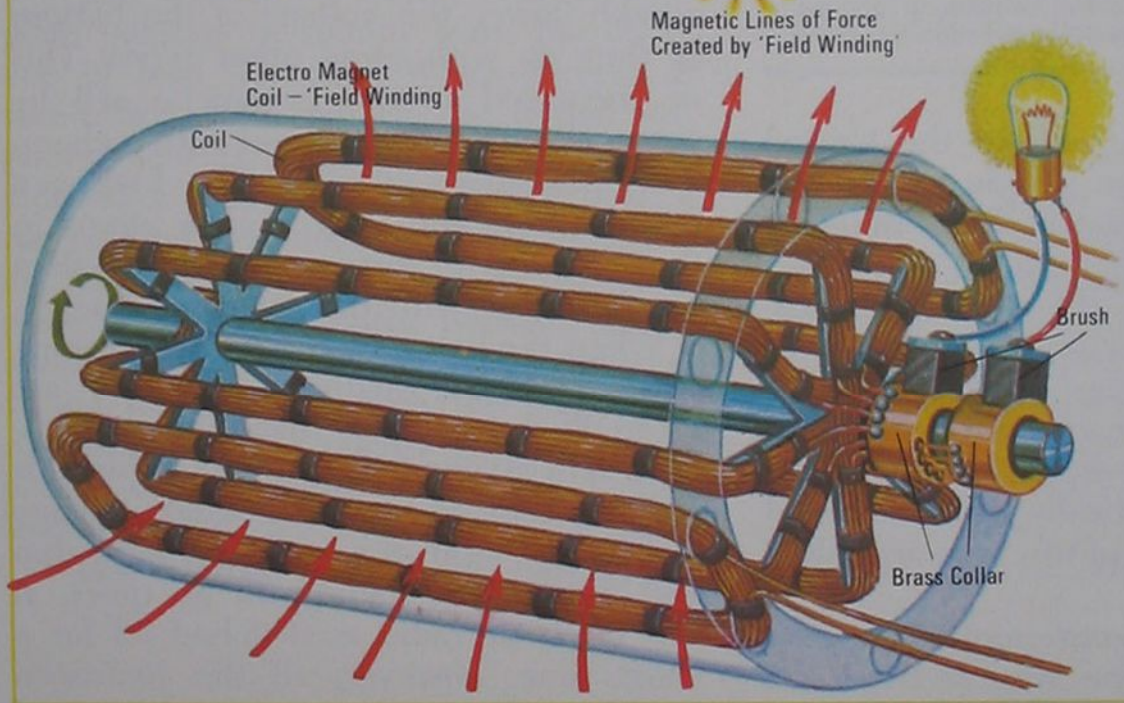
When some kind of 'driving force' is applied to the wire, the wandering electrons are organized into a steady one-way drift. The driving force is simply a difference of electrical 'pressure' (voltage) between the ends of the wire. It is provided by either a battery or generator. Electrical 'pressure' starts the drift of electrons by pushing the loosely held electrons from the first atom in the line to the next, and so on.

A current of electricity must have a completely unbroken path, or *circuit*. If we could follow a current as it flowed along a wire we should eventually arrive back at our starting point.

Wires which carry an electric current are often made of copper. Copper, like most metals, is a good *conductor* of electricity. It has plenty of free electrons, so a current has little difficulty in travelling through copper. Materials such as rubber and plastics are good *insulators* (bad conductors). Their atoms do not have any loosely held electrons. When an electric current flows through a conductor that offers resistance to its flow it heats the



The generator works on the remarkably simple principle that every time a wire is moved through the 'lines of force' which surround a magnet a voltage is set up in the wire and a current of electricity will flow through it, providing the ends are joined. A simple generator is a coil of wire rotating between two magnets arranged with unlike poles (a north and a south) facing each other. The current produced by the rotating coil is not steady. It is greatest when the coil is cutting straight across the lines of force (1). No current is produced when the coil is moving *along* the lines of force (2).

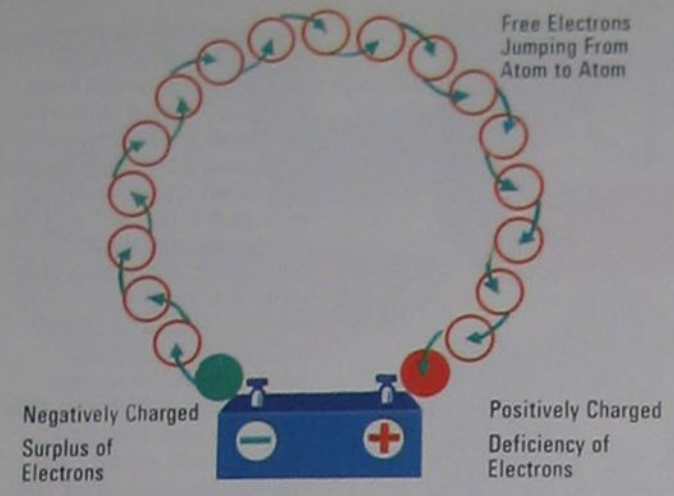


A practical generator has several coils placed like the spokes of a wheel to minimise the current fluctuations. They are wound on an iron core which helps to concentrate the magnetic lines of force they cut. In the diagram the iron core has been removed for clarity. The magnetic field is produced by two electromagnets (field windings).

conductor up. If the conductor is made of suitable *resistance* wire it will glow red and give off a good heat. This is the principle used in electric fires.

If conditions are suitable and the right type of resistance is chosen it will glow white hot and can be used to illuminate a room and light up the road ahead of an automobile (see Lighting).

Electricity for lighting, heating, etc., is generated by what are called *generators*. These machines make use of the fact that when a wire moves through a magnetic field a current is set up, or *induced*, in the wire. In an alternator the wires are arranged in a circle around a rotating shaft called the *armature*. The current is taken from the wires through slip rings on the shaft which make contact with two fixed *carbon brushes*. As the wires rotate they move downwards through the magnetic field and then upwards. This means that the direction of the induced current keeps changing—it



Above: An electric current is a movement, or flow, of 'free' electrons, the tiny particles which usually circle the nucleus of an atom. The electrons jump from atom to atom when there is a difference of electrical 'pressure' (voltage) between the ends of a wire. This voltage is produced by ensuring that the atoms at one end of the wire are short of electrons (positively charged) while those at the other end of the wire have a surplus of electrons (negatively charged). By convention, a current is said to flow through a circuit from the positive terminal of a battery to the negative terminal. In fact, the moving electrons flow in the other direction.

is an alternating current. In the United Kingdom the power supply mains use current that alternates fifty times a second: it is said to be a 50 cycles per second supply. In the United States, 60 cycles per second are used.

Direct current can be obtained by fitting a *commutator* instead of slip rings. This device keeps reversing the current to compensate automatically for the natural reversals. Machines of this type are called *dynamos*.

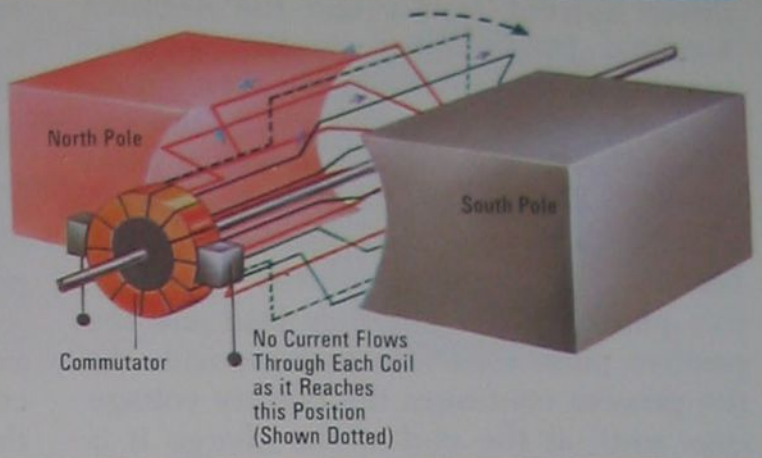
Direct current electric motors are constructed in the same way as dynamos. When they are switched on the electric current flows through the wires around the armature setting up a magnetic field around them. This field interacts with the main field of the rotor causing the wires on one side to be forced down and those on the other side to be forced up. This causes the armature to rotate and drive anything connected to the motor. Alternating current motors are constructed in a slightly different way, but work on the same principle.

Batteries generate electric currents through chemical action. A popular type, the *dry cell*, which is widely used to power electric torches, transistor radios, etc., uses a zinc case filled with sal ammoniac in the centre of which is a carbon rod. Chemical action in the battery leaves the carbon rod positively charged and the zinc case negatively charged. This battery is of the Leclanche type, named after its inventor. It is one of a class of batteries that cannot be recharged—the chemical actions that generate the electricity cannot be reversed and the battery loses its current after it has been in service for a while. Batteries of the Leclanché type are the most widely used dry batteries because the hydrogen bubbles that form on the carbon rod when the battery is delivering current are rapidly removed and cannot quickly lower the voltage of the battery as they do with some other types. This is prevented in the Leclanché cell by surrounding the carbon rod with a chemical, manganese dioxide. The hydrogen bubbles combine with oxygen atoms in the chemical to form water, which then simply mixes with the sal ammoniac.

When the battery has been on for some time, however, hydrogen bubbles are given off more quickly than they can combine with oxygen to form water. When this happens they do cause the battery voltage to fall. The light of a torch will grow dim and a transistor radio will go quiet. If the torch or radio is switched off for a short time, however, all the hydrogen bubbles will have time to combine, and when the battery is switched on again the torch will glow brightly and the radio will give full volume. Eventually, however, batteries of this class, which are known as *primary* batteries, do become fully discharged and cannot be used again.

If we want a battery that can be recharged when it has become fully discharged after prolonged use we must use one of the *secondary* or *storage* batteries. The most familiar examples of secondary batteries are those used in

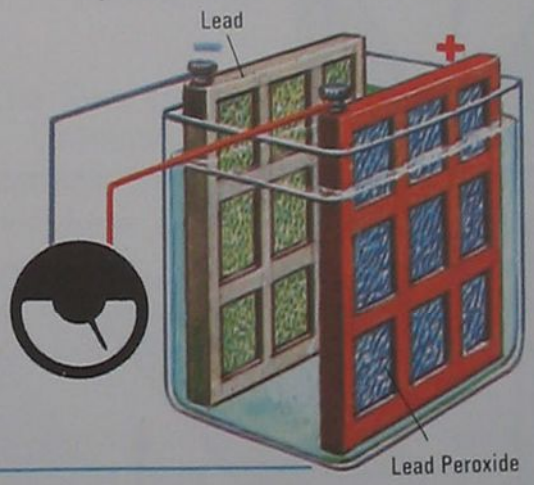
Right: An electric motor is the reverse of a generator. A current flowing through a coil makes it behave as though it were a magnet with its own north and south poles. These poles attract or repel the poles of fixed ordinary magnets (unlike poles attract, like poles repel) and the combination of these forces rotates the coil. The rotation of the coil will continue indefinitely providing the *direction* of the current is changed twice every rotation—in fact, whenever the plane of the coil is at right angles to the magnetic field. The device which automatically changes the direction of current flow is called a commutator. A practical motor has a number of coils.

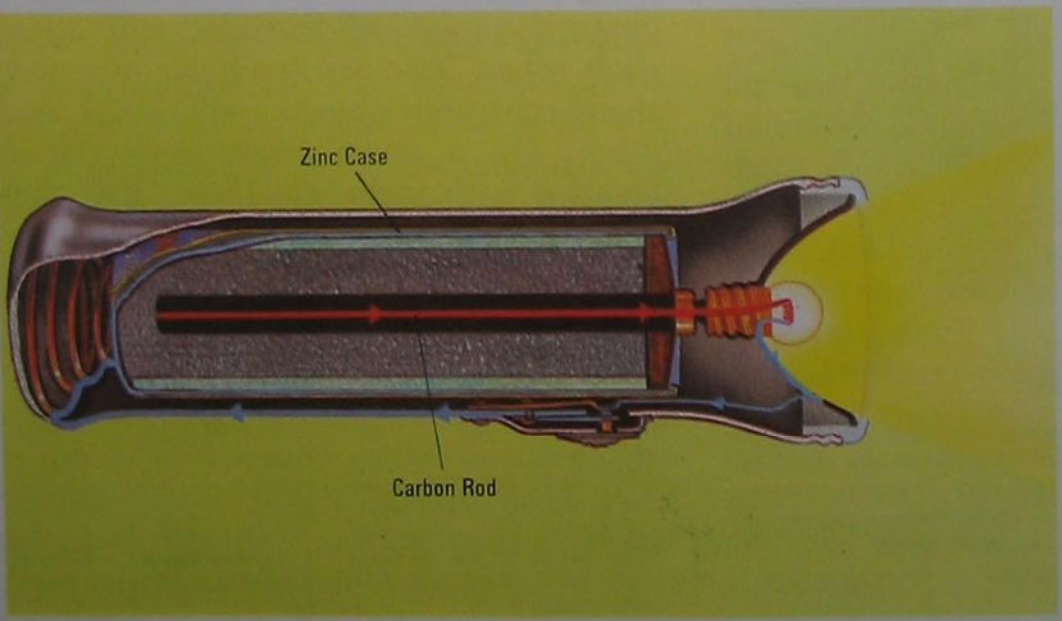


automobiles. These particular secondary batteries consist of a jar filled with dilute sulphuric acid in which two plates are immersed. The current supplied by the battery is drawn off from two terminals, one on the top of each plate.

When the battery is fully charged, one plate consists of spongy lead: the other one of lead peroxide. When current is taken from the battery the dilute sulphuric acid is split into its component molecules, which are hydrogen and a special kind of molecule called a sulphate ion. Complex chemical reactions then take place at the two plates between these molecules and the component molecules of the material of which the plates are composed. This results in the two plates being gradually converted into lead sulphate.

When a large part of the two plates has been so converted the battery voltage falls to a very low value and it can no longer be used. To recharge a secondary battery it is connected to a direct current power supply having a voltage slightly greater than that of the battery itself. The positive terminal of the battery is connected to the positive terminal of the





Above: A plate made of lead becomes negatively charged and a plate made of lead peroxide becomes positively charged when both stand in the same container of sulphuric acid.
Left: Chemical action in a dry cell battery leaves the carbon rod positively charged and the zinc case negatively charged creating a difference in the electrical potential (voltage) which results in a flow of electricity. The arrows show the 'conventional' direction of the current.

direct current supply and the negative terminal is connected to the negative terminal. The power supply then drives current through the battery in the opposite direction to that in which it flows when the battery is providing the power. This produces chemical reactions in the battery which gradually turns the negative plate back into spongy lead and the positive plate back into lead peroxide. As the process continues the battery voltage rises until at the end of the charge it is at a maximum.

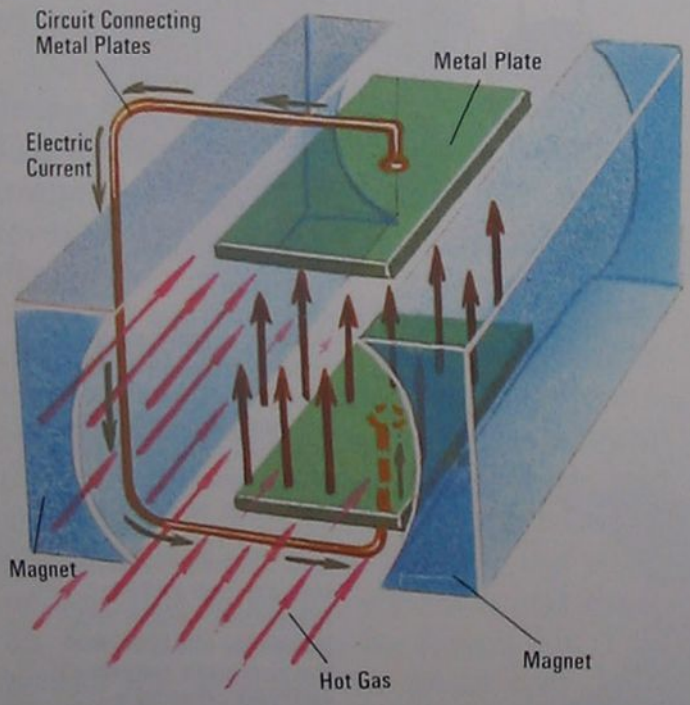
Other types of secondary battery are in use or are being developed; but none has as yet won the same wide acceptance as has the lead acid battery. Nickel-cadmium batteries have some advantages. A particularly promising type of battery is the sodium-sulphur type.

Electro-chemical techniques somewhat similar to those used in batteries are employed in electroplating (see Electroplating).

There are a number of other ways of producing an electric current. A very small current is produced, for instance, when the junction between two different metals is heated. This device is called a *thermocouple*. Another method is given the name *magnetohydrodynamics* (MHD). This is simply a way of converting heat energy to electrical energy at high temperatures and employs no moving parts. It is based upon the fact that gases at high temperatures can conduct electricity. Whenever a conductor cuts across a magnetic field a current is generated in that conductor no matter whether it is a metal, a liquid or a gas. Consequently, if the hot gas from burning fuel is swept between the poles of a magnet a current is generated in it which can be picked up by pieces of metal (electrodes) within the tube.

The familiar *static electricity* effects occur when an object such as a comb or a pith ball is given an excess of electrons, or if a number of them are removed. It then becomes either negatively or positively charged. Positively and negatively charged pieces of material will attract each other. Two positively or two negatively charged objects will repel each other. On a much larger scale, clouds charged with static electricity lose their charge by means of an electric spark which we call lightning (see Lightning).

Left: A small current is generated when light falls on certain metals, such as selenium. This is the basis of the cells which power spacecraft. Photographic lightmeters work on the same principle.



Very hot gases will conduct electricity and a current of electricity will be produced in them if they are made to cut magnetic lines of force. This current can be picked up by metal electrodes. This is called magnetohydrodynamics (MHD) and is a possible method of producing electricity in the future.

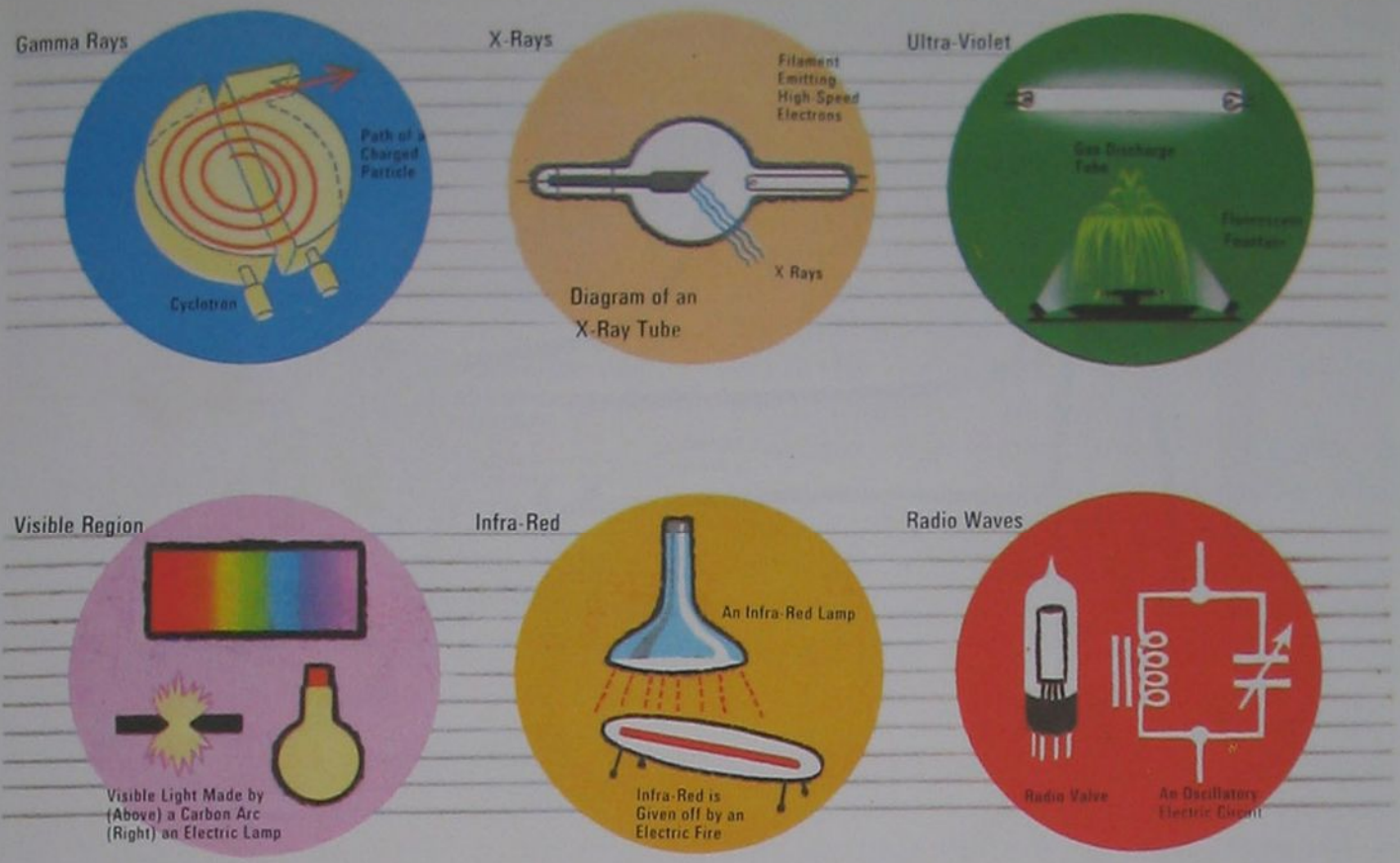
Talking points

*Take a comb and rub it against the sleeve of a pullover. If you do this for about a minute, you will find that the comb will attract small pieces of paper like a magnet. The cause of this is static electricity. Find out how this works.

*Man has become very dependent on electricity, as can be seen from the chaos caused by a power failure. How much do you depend upon it in your everyday life?

Articles to read

Communications; Electromagnetic radiation; Electronics.



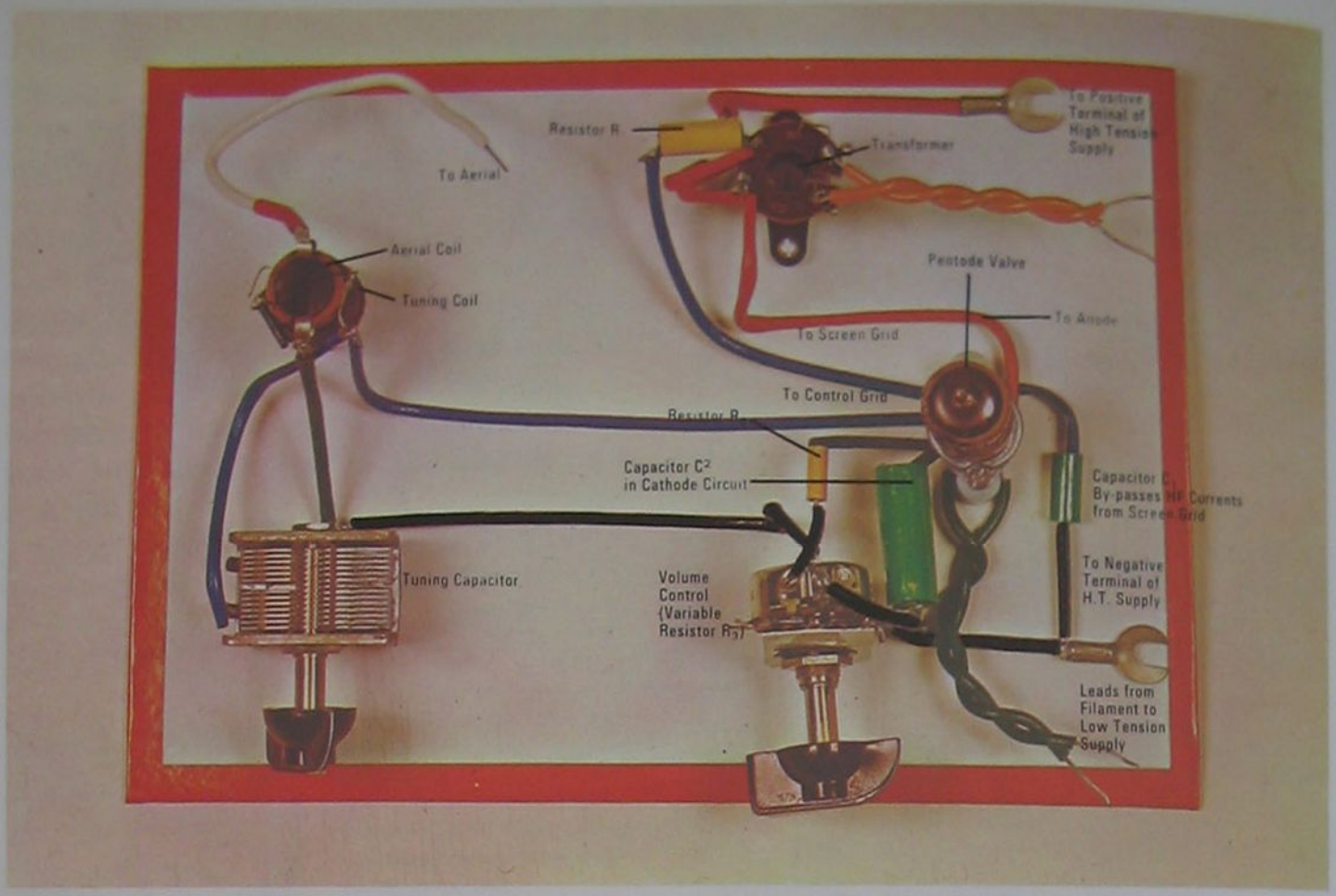
Electromagnetic radiation Light, ultra-violet and infra-red rays, radio waves and X-rays, are all forms of *electromagnetic radiation*, and differ only in their wavelengths. The unit of length for measuring electromagnetic waves is the Ångstrom, named after the 19th-century Swedish physicist Anders Ångstrom. An Ångstrom is equal to one hundred-millionth of a centimetre.

All forms of electromagnetic energy known to science can be arranged in order of wavelength in the *electromagnetic spectrum*. Visible light has a relatively small place in the spectrum, ranging from about 7600 Ångstroms for red light to about 4000 Ångstroms for violet light. Infra-red or 'heat' rays are longer than red light in wavelength and are invisible. Ultra-violet, X-rays and Gamma rays have shorter wavelengths than violet light and can only be detected using special photographic films. Much longer again than infra-red rays are short, medium and long radio waves.

The Sun, the stars and other bodies in the Universe give off electromagnetic radiations of many kinds. The Earth's atmosphere stops many of these reaching the ground, but it lets through others, such as light and short radio waves. (See Heat; Light; Ultra-violet; X-rays.)

Electronics is a word that is hard to define. It was probably first used in the 1930's to describe industrial applications of the radio valves (tubes) developed for use in radio. Then transistors were invented and the name was applied to them as well. Today, valves (tubes) and transistors are used more outside the radio field than in it and radio is now thought of as just one of the many branches of electronics.

Apart from a valve, or more usually today a transistor, the basic electronic circuit also includes components known as *resistors* and *capacitors* and occasionally *inductors* as well. A resistor offers resistance to an electric current: it is used



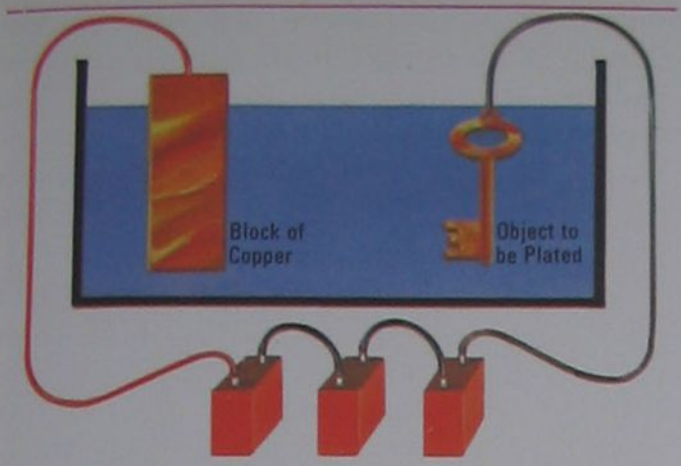
An example of electronic components including capacitors, resistors and valves (tubes) arranged in a model circuit diagram of a simple radio receiver.

to control the flow of current in electronic circuits. Capacitors consist basically of two metal plates separated by an insulating layer. They possess the ability to store electricity for short or long periods and so are very useful in electronics. Inductors are coils of wire. They too can store electrical energy—in the form of a magnetic field which surrounds the coil when a current flows through it.

One important class of electronic circuits, known as logic circuits, forms the building blocks from which computers are made. Made from transistors, resistors and capacitors they can, for example, be designed to give an output signal when there is a signal on both of the inputs: this type is called an AND gate. Alternatively, they can be designed to give an output signal when there is an input signal on only one of two input connections: this type is called an OR gate. Many other arrangements are possible.

By using them and similar circuits electronics engineers are able to design equipment that will switch on TV cameras on spacecraft as far away as the Moon; switch on instruments on spacecraft approaching the planet Venus; and control the ignition circuits of the family automobile. The introduction of cheap microelectronic circuits in the late 1960's is greatly speeding up the spread of electronic control.

Electroplating This is a process whereby decorative or protective metallic coats are deposited on objects by placing them in a chemical bath through which an electric current is flowing. Objects such as teapots, candlesticks, etc., made from a base material can be made to look very attractive by depositing a thin layer of silver on them. This is the process known as silver plating. Parts of automobiles are protected by plating them with copper or nickel, and the appearance of many automobiles is improved by coating exterior metal work with chromium.



The principle of electroplating. When a block of copper and an object such as a key are dipped in a solution of copper sulphate and a current passes between them copper is gradually deposited on the key.

Chromium plating is widely used to coat steel and gives a lasting, shiny finish. A hard layer of chromium protects a thicker layer of nickel underneath from scratches. Steel is also plated with tin to form tinplate, and with zinc to form galvanized steel. Silver plating is widely used to plate cutlery.

A direct current flows through a plating bath containing a solution of the metal to be deposited. The negative side of the supply is connected to the object, which is immersed in the bath. The positive side of the supply is connected to a bar which, like the bath itself, is made from the metal to be deposited. This bar too is immersed in the bath.

When the direct current supply is switched on the metal atoms in the solution, which are positively charged, are attracted by the object because it is negative, and drift towards it. When they reach it they firmly adhere to it.

Elements All matter is made up of a number of basic chemical substances called *elements*. These cannot be split up into smaller units by normal chemical or

This table shows all the elements up to No 88 (those from 89 up to 103, including uranium at 92, are increasingly similar). Each square represents an element and contains its name, its symbol and its atomic number. The elements are listed horizontally in the order of their atomic numbers. Elements which have chemically similar properties fall under one another in the same vertical column (for example, the inert gases helium, neon and so on; copper, silver and gold which make up one group; and the steel-hardening elements chromium, molybdenum and tungsten which make up another group.

All the metals are below and to the left of the heavy line. The non-metals are above and to the right. Hydrogen, the 'odd man out', is in a thick box by itself.

Metals

Non-Metals

Metalloids—elements having characteristics common to metals and non-metals

Inert gases, which seldom combine to form stable compounds with other elements

Lanthanide series (rare earths)

Actinide series. It includes Uranium (U) 920

PERIODS																	
	Hydrogen H 1																Helium He 2
	Lithium Li 3	Beryllium Be 4											Boron B 5	Carbon C 6	Nitrogen N 7	Oxygen O 8	Fluorine F 9	Neon Ne 10
	Sodium Na 11	Magnesium Mg 12											Aluminium Al 13	Silicon Si 14	Phosphorus P 15	Sulphur S 16	Chlorine Cl 17	Argon A 18
	Potassium K 19	Calcium Ca 20	Scandium Sc 21	Titanium Ti 22	Vanadium V 23	Chromium Cr 24	Manganese Mn 25	Iron Fe 26	Cobalt Co 27	Nickel Ni 28	Copper Cu 29	Zinc Zn 30	Gallium Ga 31	Germanium Ge 32	Arsenic As 33	Selenium Se 34	Bromine Br 35	Krypton Kr 36
	Rubidium Rb 37	Strontium Sr 38	Yttrium Y 39	Zirconium Zr 40	Niobium Nb 41	Molybdenum Mo 42	Technetium Tc 43	Ruthenium Ru 44	Rhodium Rh 45	Palladium Pd 46	Silver Ag 47	Cadmium Cd 48	Indium In 49	Tin Sn 50	Antimony Sb 51	Tellurium Te 52	Iodine I 53	Xenon Xe 54
	Caesium Cs 55	Barium Ba 56	Lanthanide series 57-71	Hafnium Hf 72	Tantalum Ta 73	Tungsten W 74	Rhenium Re 75	Osmium Os 76	Iridium Ir 77	Platinum Pt 78	Gold Au 79	Mercury Hg 80	Thallium Tl 81	Lead Pb 82	Bismuth Bi 83	Polonium Po 84	Astatine At 85	Radon Rn 86
	Francium Fr 87	Radium Ra 88	Actinide series 89-103															

physical means, such as treatment with acid, heat, or electricity.

Most elements will combine with other elements to form a *compound*. This compound has entirely different properties from those of its constituent elements. For example, common salt, or sodium chloride, is a compound formed when sodium combines with chlorine. It is totally different from sodium (a light metal) and chlorine (a poisonous gas).

A compound must be distinguished from a *mixture*, in which the component parts are uncombined. A mixture can be separated *physically*, whereas a compound must be separated *chemically*.

Every element is made up of a number of identical tiny *atoms*. Each atom consists of a number of minute particles—protons and neutrons—in a central *nucleus*, around which circle even smaller particles called *electrons*. (See Atom.) It is the electrons which determine how the various elements combine together.

Most elements occur in nature as a mixture of two or more *isotopes*—forms with the same number of protons but a different number of neutrons. The isotopes have the same chemical properties (which depend on the number of protons) but different weights. The number of protons in the nucleus is called the *atomic number*.

The elements can be arranged in order of their atomic numbers so that they fall into a fairly regular pattern, with breaks at certain intervals, or *periods*. Such an arrangement is called the *periodic table*. Elements in the same vertical *group* in the table have similar properties. For example, in the second group are the light metals beryllium, magnesium, calcium, strontium, barium and radium, which all have distinct similarities.

In the table on the previous page the elements are listed horizontally in order of increasing atomic number. There are 92 natural elements; a number of artificial ones are obtained by bombarding natural elements with atomic particles.

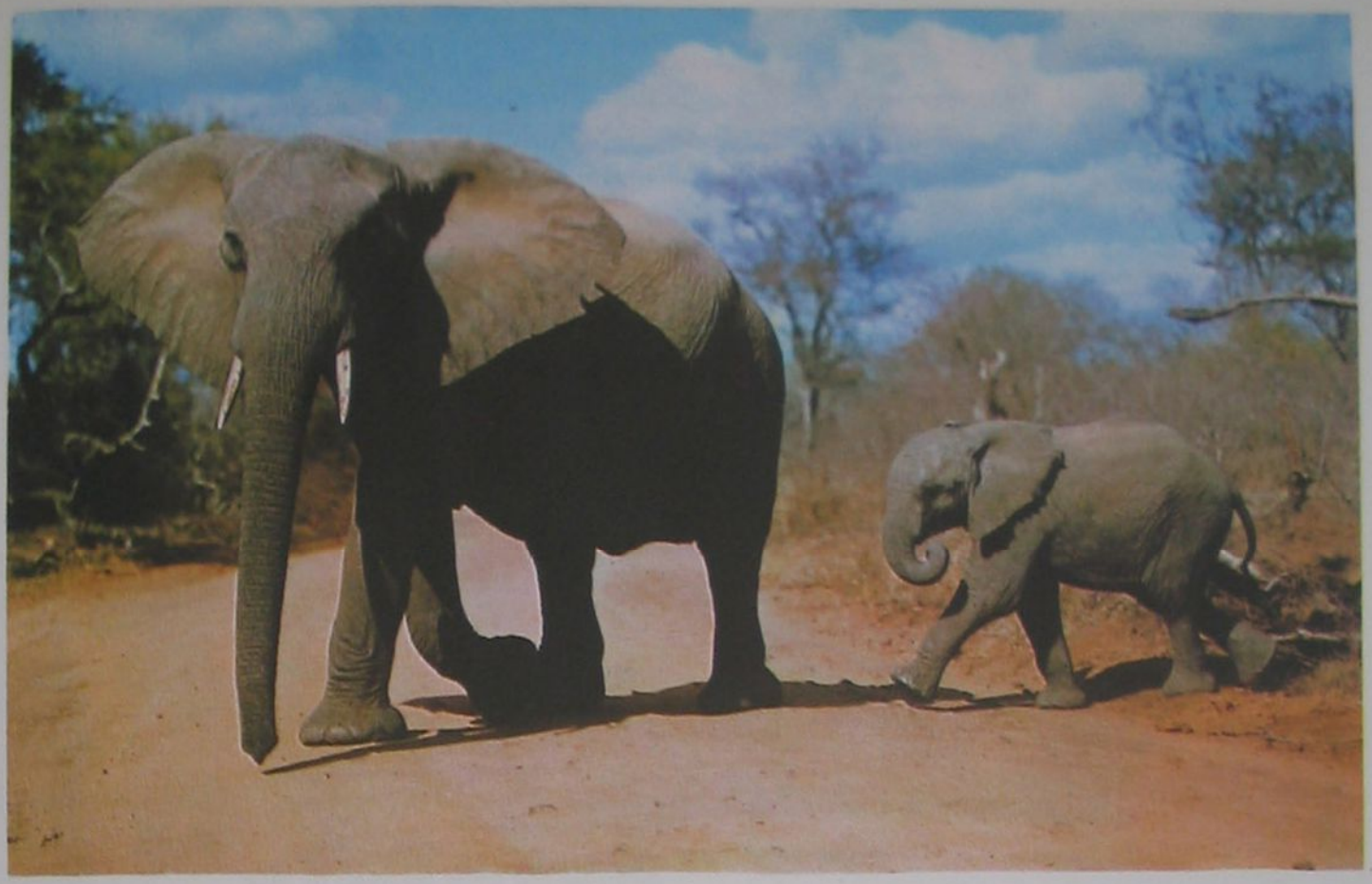
Elephant Today, there are two species (kinds) of elephants—the African and the Indian, or Asian. But, from fossils, biologists know of some 350 extinct species. Some of these lived at the same time as prehistoric man, but others roamed the Earth up to 60 million years ago.

The earliest elephants were no bigger than pigs, and looked little like their present-day descendants. From these developed such creatures as the shovel-tusker, with its big, shovel-like lower jaw, the mastodon, and the hairy mammoth.

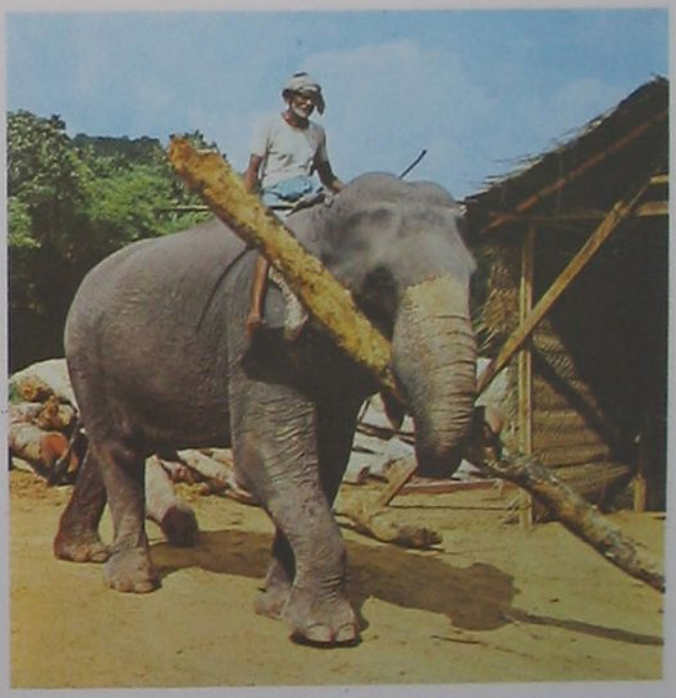
The later elephants all had long trunks and big *tusks* (curving teeth)—characteristics of the two living elephants. An elephant's trunk is perhaps the most remarkable of all animal organs. It is the long, drawn-out nose and upper lip, which the elephant uses as an extra limb particularly to gather food. Its tip is so sensitive that it can pick up a single peanut. Yet the trunk's muscles are strong enough to pick up massive logs. The elephant can use its trunk to suck up as much as 12 pints of water, which is then squirted into its mouth—or on to its back.

The tusks are enormously overgrown upper front teeth. They are valuable for their ivory, and may weigh up to 250 pounds. Elephants are huge. An African male may reach a height of 12 feet and a weight of seven tons or more—the biggest of all living land animals. The Indian species is smaller, but both have thick, pillar-like legs. They can run quite fast, but cannot jump. Elephants are vegetarians, and may eat as much as 500 pounds of grass and leaves in a day, plus 50 gallons of water.

African legends tell of a hidden valley where elephants go to die. Because of the amount of valuable ivory that would be present in such a place, many explorers and hunters have made expeditions to search for the 'elephant graveyard'. None of them has found it. The remains of a number of elephants have been found together on various occasions; but it is thought that such 'graveyards' may have been caused when a herd of elephants was wiped out by a deadly disease.



Above: The African elephant is difficult to tame. It is the largest land-living animal in the world. A fully grown African elephant may be more than eleven feet high at the shoulder and may weigh seven tons.



Right: The Indian elephant. Wild elephants can be trained to do heavy work and are often put to valuable use in timber mills.

Apart from being smaller than African elephants, Indian elephants have smaller ears, and their trunks differ at the tip. Both can be tamed and used to pull and carry great loads, but tame elephants are much more common in Asia than Africa.

Elizabeth I (1533-1603) was the daughter of Henry VIII and Anne Boleyn. She became queen of England on the death of her half-sister Mary in 1558. When she came to the throne, England was fighting a costly war with France and the Treasury was almost bankrupt. She ended the war and improved the financial situation. Elizabeth also re-established the Anglican Church which had been restored to Roman Catholicism during Mary's reign.

Elizabeth was a skilful stateswoman and used the proposals of marriage from the kings of Europe to England's advantage. She survived many plots against her by keeping an efficient secret service. This was run by Lord Burghley, her most trusted adviser. Although Elizabeth tried to prevent it, Spain went to war with England in 1585. The Spanish invasion fleet, the *Great Armada*, was

defeated by the English fleet commanded by Sir Francis Drake and was then destroyed by storms in 1588.

During Elizabeth's popular reign, trade and exploration flourished, and the foundations of Britain's Empire were laid.

Elizabeth II (1926-) became queen of the United Kingdom and head of the Commonwealth of Nations on the death of her father, George VI, in 1952. In 1947 she married her third cousin, Lieutenant Philip Mountbatten, R.N., a prince of Greece, descended from the Danish royal family. He renounced his Greek title, and on his marriage was made a British prince and Duke of Edinburgh.

King George VI died while Elizabeth and Philip were in Kenya, on an official

Left: Elizabeth I loved elaborate clothes and in old age wore heavy make-up and a wig. Her reign saw the birth of England's colonial empire. Below: Elizabeth II and her family—a picture taken for her silver wedding in 1972.

Delicate embroidery in silk and metal threads decorates this 18th-century tea apron of silk taffeta. Such aprons were worn by a lady while making tea at the table.

tour. Since the coronation in 1953, they have travelled to many parts of the world on goodwill tours. The Queen and Prince Philip have four children – Prince Charles, Prince Andrew, Prince Edward and Princess Anne. Elizabeth II is queen not only of Britain, but also of several other Commonwealth countries.

El Salvador is a small, densely populated country in Central America. It has 3,390,000 people living in an area of 8,260 square miles. Almost all the people are *mestizos*, that is, people of mixed European and Indian descent. The country's capital is San Salvador. Coffee and cotton are the chief export crops. The people also grow rice and maize for their own needs. El Salvador belonged to Spain from the 1500's until 1821, when it became part of Mexico. In 1841, it became an independent republic.

Embroidery is a form of decorative needlework in which the stitches form a design on cloth. It is an art that has been practised for thousands of years in a variety of styles and forms.

The thread used in embroidery may be silk, cotton, wool, linen or almost any other material available, including costly metallic fibres, such as gold thread. Pearls, sequins or beads can be worked into the design. Brilliant colours are often used, but white on white designs and other delicate combinations are common for lingerie and handkerchiefs. Patterns may cover the entire article or be confined to borders and decorative

This location map shows the position of El Salvador.

bands. Tapestries are sometimes embroidered, but tapestry designs are usually woven into the fabric.

Some embroidery stitches, such as chain stitches, daisy stitches and French knots may suggest forms and shapes in themselves. Other stitches may be laid on closely to fill in a particular area of the design. One kind of embroidery, called *cut-work* resembles lace. The design is cut out and outlined in embroidery. *Appliqué* work consists of fabric shapes sewn on to the article. *Quilting, patchwork* and *needlepoint* are other embroidery techniques.

Embroidery is mentioned in the Bible, and examples still exist of embroidery from ancient Egypt. The Chinese and Indians have been embroidering traditional designs for thousands of years. Embroidery became popular in Europe after the Crusades, especially for religious vestments and church decorations. Later embroidery was used to decorate ornate fashions and home furnishings. Today, machines can duplicate most embroidery techniques.

Emerson, Ralph Waldo (1803-1882), is one of the leading figures in the history of American literature and thought. He was born in Boston, Massachusetts. After graduating from Harvard University, he briefly became a minister of religion before turning to a life of writing and lecturing. He wrote many poems, including *Concord Hymn* and *Brahma*, and essays. He believed that every man should be guided by his conscience in matters of religion and that Americans should not try to copy Europeans.

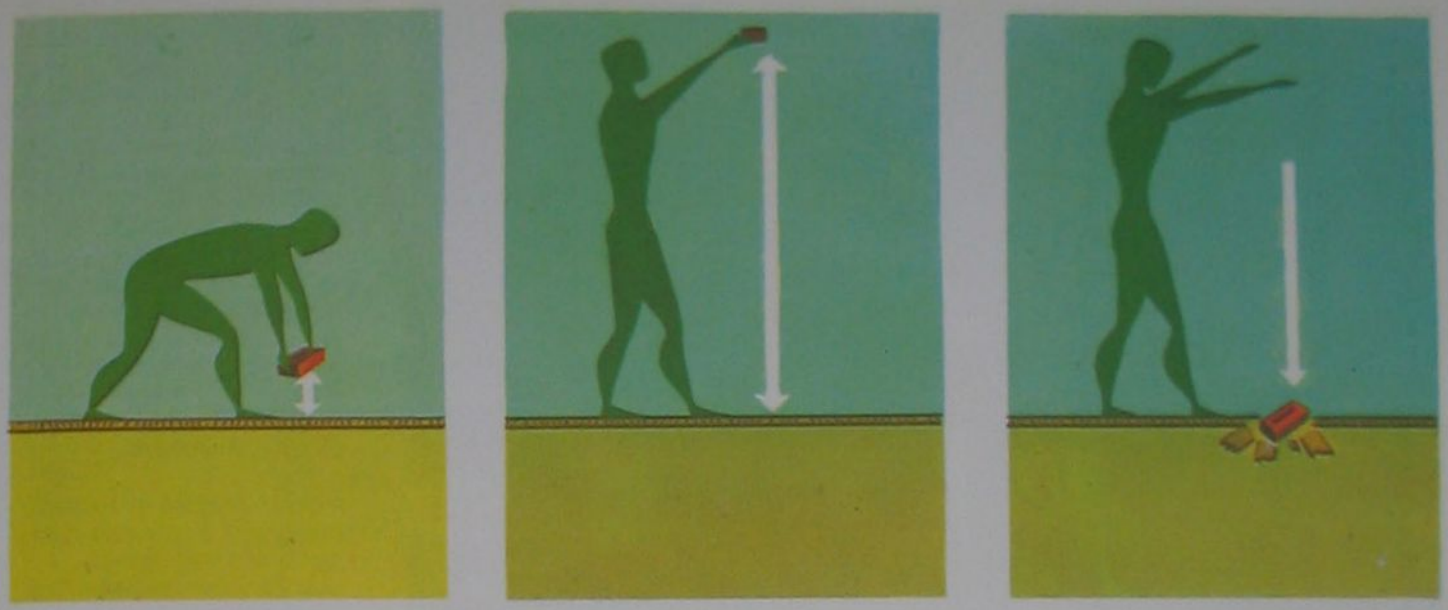
Emu, the largest bird in the world after the ostrich, is found in eastern Australia. Its short feathers are a dull, mottled brown, and it grows to more than 6 feet in height. Although it cannot fly, the emu is a very fast runner. It relies on its speed for safety, but when it is cornered it can kick viciously. The hen sometimes makes a loud booming sound, produced by a pouch in her windpipe.

Energy is the ability to do work. Our muscles release energy which we expend as work every time we use them. When we push or pull an object with our muscles, we produce a *force* on the object. *Power* is the rate at which we work.

Energy exists in several forms. There are two basic kinds of energy—potential energy and kinetic energy. *Potential* energy is the energy of position. For instance, the weight that drives an old-fashioned clock has potential energy when it is at the top. As the weight falls, the potential energy is changed into *kinetic* energy, or energy of movement.

Other forms of energy are *electrical, heat, chemical, sound, nuclear,* and *radiant* energy. These various forms can be changed into each other. For example, the chemical energy of petrol is converted to heat energy in the cylinder of a car engine; this is converted into kinetic energy as it moves the pistons; to electrical energy in the generator; to light (radiant energy) in the headlamps; to sound in the horn; and so on. At every stage some energy is

The emu, a flightless bird found in eastern Australia, can run at up to 30 miles an hour.



In lifting the brick (left) the man does work and transfers potential energy to the brick. As it is lifted (centre) the brick gains more potential energy. When it is dropped (right) its potential energy is converted into kinetic energy.

converted to heat, such as heat due to friction in the moving parts or heat from the lamp. When we do not want the heat, we regard this as 'lost energy'. However, energy in fact is never lost—only converted to another form.

Chemical energy is changed directly into kinetic energy when we use our muscles. The chemical energy comes from the food we eat. The source of almost all these forms of energy is the Sun. The radiant energy from the Sun has produced most of the fuels that we use, including coal, wood and petroleum, and the food we eat. The water that powers hydroelectric generators was raised into the sky as vapour by the Sun's heat, later to fall as rain and fill rivers.

Nuclear energy is produced by radioactive elements like uranium and plutonium. The Sun produces radiant energy by consuming hydrogen in another nuclear process. (See Nuclear Energy.)

England forms part of the United Kingdom of Great Britain and Northern Ireland. It is bordered on the north by Scotland and on the west by Wales (see British Isles, United Kingdom).

England's border with Scotland passes through the Cheviot Hills. To the south lies the Pennine Chain, a hilly region which runs down the centre of England like a 'backbone'. To the west of the Pennines are the beautiful Cumbrian Hills, which contain many lakes. This region is called the Lake District.

Fertile plains lie on both sides of the Pennines. Rich coal deposits in the north-east have led to the growth of a large industrial area around the city of Newcastle-upon-Tyne. Further south, the Yorkshire plain is an important farming area, with more coalfields. Industrial cities in this region make woollen textiles, steel and manufactured goods.

Much fertile farmland lies in the generally wet area west of the Pennines, especially in the Cheshire plain. Cotton manufacturing grew up around the cities of Manchester and Liverpool, which are both important ports.

Central England, called the Midlands, is a rich plain where many crops are grown and where large numbers of cattle are reared. Coal and iron ore deposits have led to the growth of many great industrial towns. The city of Birmingham is the centre of a great manufacturing area.

East of the Midlands lies East Anglia and the Fenlands, which are low-lying, highly fertile regions. Much of the land has been reclaimed from swamp or marshland. Farms in these areas produce much of England's wheat and sugar-beet.

Although England is one of the most heavily industrialized countries in the world its countryside and small villages are famous for their beauty.

Left: A tiny church stands by the side of a thatched cottage at Welford-on-Avon in Warwickshire. The art of thatching is slowly dying out although attempts are being made to train thatchers.

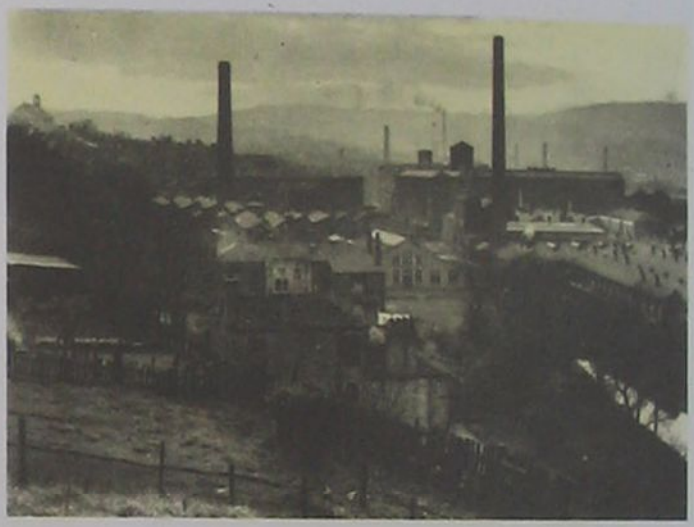
Below: A mass of factory chimneys dominates the small town of Milnesbridge, near Huddersfield.

The Midlands are partly bounded by England's two main rivers. The River Severn flows south and west to the Bristol Channel. The Thames flows eastwards to the North Sea. Many important towns lie in the Thames basin. The most important is London, the capital of Britain and one of the world's largest cities and greatest ports. More than 7,000,000 people live in the Greater London area.

South of London lie hills of chalk and other rocks, separating rolling plains. South-eastern and south-central England has much good farmland. The Isle of Wight lies south of the great port of Southampton. Many towns along the south coast are important holiday resorts. The rocky south-western peninsula is a wet but generally warm region. Its bleak granite uplands are exposed to the wind and rain. Bristol, another important port, lies in the sheltered Severn estuary to the north.

The first known people in the country settled there about 25,000 years ago. Celts invaded the country about 2,500 years ago, and Celtic culture was dominant when the Romans began to conquer it in A.D. 43. The Romans stayed for nearly 400 years.

When the Roman legions left, invaders from across the North Sea and Channel entered Britain. They were called Angles,



Saxons and Jutes. The Angles of the Midlands and North gave their name Angleland or England to the country. From about 787 a second wave of invaders from the same parts of Europe, the Viking Danes, began to attack England. Only in 954 did the rule of one king over all England become permanently established.

In 1066, the Normans, descendants of Vikings living in northern France, invaded England. At the Battle of Hastings, William, Duke of Normandy, defeated the Anglo-Saxons under their king, Harold II, and became King William I.

The highest mountain in England is Scafell Pike (3,206 feet) in Cumberland. The Thames is the longest river flowing 215 miles. The place in England that has received the most rainfall is a village in Cumberland upon which 257 inches fell in 1954.

At first, the Normans ruled England under a feudal system (see Feudal System). Under this system, the king was at first all-powerful. But in 1215, the rich land-owning barons forced King John to accept Magna Carta, a document intended to limit the power of the king.

The king always had a council of important men to advise him. In the 1200's, this council began to include representatives of all parts of the country, and became the ancestor of what we now call parliament. In the same period, the English conquered Wales (see Wales).

During the 1400's, two rival families, York and Lancaster, fought civil wars

A map of England

called the Wars of the Roses, from the badges of the two families. The Lancastrians won, and in 1485 their leader, Henry Tudor became King Henry VII.

For hundreds of years, the English fought the Scots. These wars ended in 1603, when the Scottish king, James VI, inherited the throne of England as James I. Although the two countries were linked under one monarch, they did not become one country, Great Britain, until 1707.

James's son, Charles I, tried to rule without parliament. As a result, civil war broke out. Parliament won, and in 1649, Charles was executed. England became a republic ruled by Oliver Cromwell. He died in 1658, and in 1660, Charles's son became king as Charles II.

In 1801, Ireland was joined with Great Britain to form the United Kingdom of Great Britain and Ireland.

During the 1800's, Britain's population expanded from 10 millions to 37 millions. Its industries developed to a remarkable degree. Britain became rich and powerful, exported manufactured goods to the whole world, and built up a vast empire.

From 1914 to 1918, Britain fought and won World War I, but it lost much of its wealth and three-quarters of a million men were killed. In 1921, southern Ireland broke its union with Britain. The north became part of a new United Kingdom of Great Britain and Northern Ireland.

In 1939-1945, Britain defeated Germany and Japan in World War II, but the war weakened Britain. From 1947 onwards Britain's empire disappeared as colonies gained independence. Many ex-colonies joined the British Commonwealth. Britain's people became more diverse. Each year, many English people emigrated, to be replaced by roughly the same number of immigrants from other countries. In 1973 Britain joined the European Economic Community.

The first man successfully to swim the English Channel was the Englishman, Captain Webb, in 1875. He crossed from Dover to Calais in 21 hours 45 minutes.

English Channel is a stretch of water between England and France. In France it is called *la Manche* (the sleeve). Eastwards it opens out into the North Sea, through the Strait of Dover, and westwards it leads into the Atlantic Ocean. The Channel is about 350 miles long; 100 miles wide at its western end, between the Scilly Isles and Ushant; and 22 miles wide at its narrowest, between Dover and Cap Gris Nez. Ferries regularly link Folkestone with Boulogne; Dover with Boulogne, Calais, Dunkirk and Ostend; and Newhaven with Dieppe. In the early 1970s, preparations began for the building of a Channel tunnel.

English language English is one of the Germanic languages. It started in Britain during the A.D. 400's when Germanic tribes—the Angles, Saxons, Jutes and Frisians—invaded the country, bringing a common language with them. Today, English is spoken in more places than any other language, although northern Chinese is spoken by more people.

About 400 million people speak English. Many of these, including people in Britain, the United States, Australia, New Zealand, and Canada, use English as their first or official language. English is taught in many other countries as a second language.

There are wide differences in the way different people pronounce English. Londoners and New Yorkers, for example, not only have different pronunciations, but sometimes use different words entirely. People from one part of the English-speaking world might have difficulty in understanding people from another part because of this.

English has changed so much throughout its history that the speaker of modern English can barely understand the original of Chaucer's *Canterbury Tales*, written in Middle English in the late 1300's. And

Opposite: Weekend cricket matches are a traditional feature of village life in England.

Old English, the original version of the language, would be completely incomprehensible today.

Enzymes are complicated chemical substances found in all living things. They act as *catalysts*—that is, they cause chemical *reactions* (changes) without being changed themselves. The changes controlled by enzymes are the biochemical ones that take place all the time in plants and animals. In fact, all the chemical processes of life are caused by enzymes. Without them, the reactions would be so slow that there would be no life.

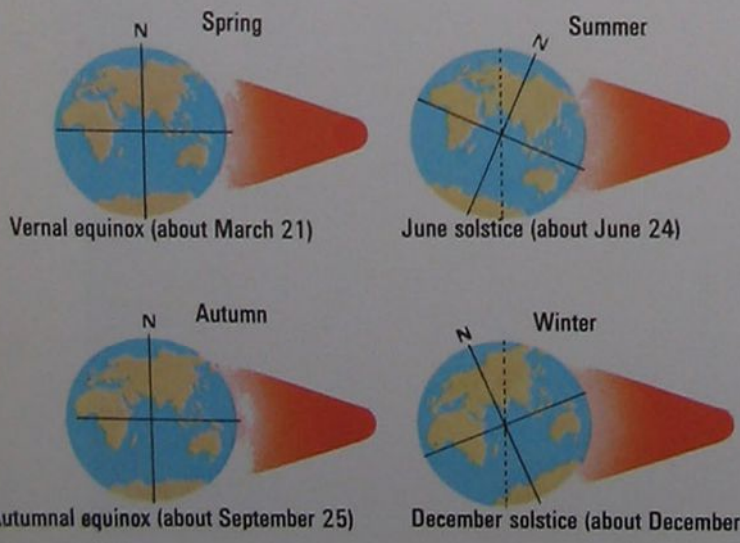
Enzymes are *specific*—that is, they control only one particular chemical change or type of change. An enzyme called *ptyalin*, for example, is found in saliva. It digests starch into a kind of sugar called maltose. (See Digestion.)

Equator This is an imaginary line drawn around the Earth at its widest part, halfway between the North and South Poles. It divides the world into two equal areas, the Northern and Southern Hemispheres.

Equinox As the Earth travels round the Sun it is spinning at a constant angle. As a result during the course of a year, the length of day and night changes continuously. First the days grow longer in the Northern Hemisphere and correspondingly shorter in the Southern Hemisphere. Then the reverse happens. The most extreme days of this cycle are the solstices—the occurrence of the longest day and shortest night and of the shortest day and longest night. In between these extremes are two points called the equinoxes, when day and night are equal all over the Earth. At the equinoxes the Sun appears to be neither in the Northern nor in the Southern Hemisphere but directly over the Equator. The *vernal* or *spring equinox*, occurring on or about March 21, marks the beginning of spring in the Northern Hemisphere. The *autumnal equinox*, on about September 25, marks the start of autumn.

The Earth's axis tilts through 23½ degrees in each direction in the course of one year. At the equinoxes the Sun is directly overhead at noon on the Equator.

The equinoxes and seasons in the northern hemisphere

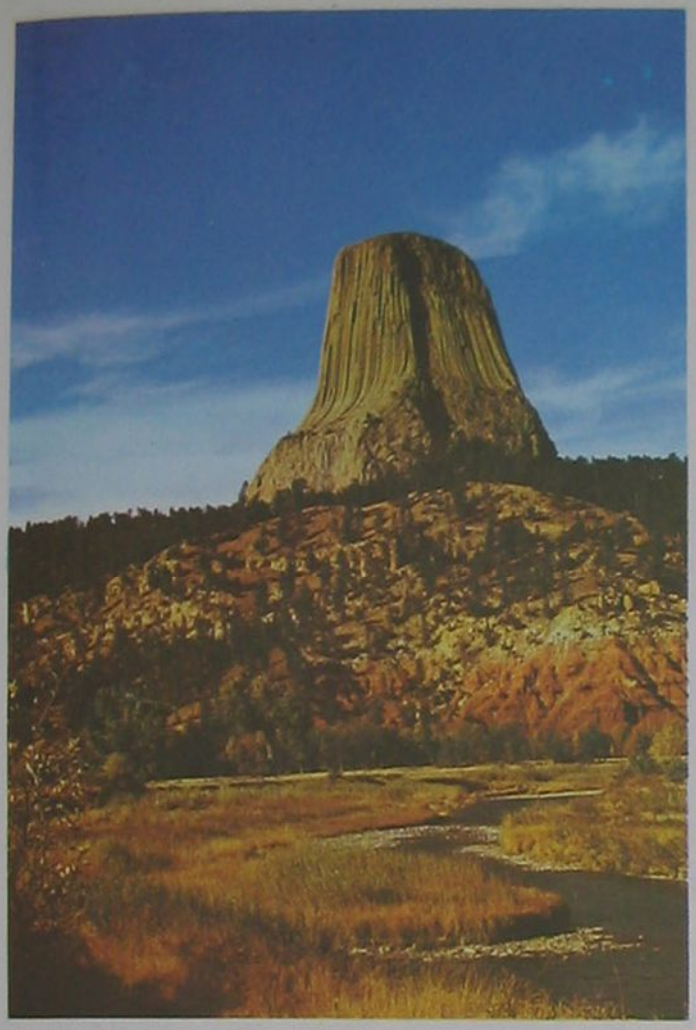


Erosion The surface of the Earth is constantly being worn away by natural forces such as running water, waves, ice, and the wind. This process is called *erosion*. Even the hardest of rocks are gradually reduced to pebbles and sand.

In most regions, running water has the greatest erosive effect on a landscape. Water moving along a stream bed continually picks up and deposits rock fragments. The scraping action of these fragments deepens and enlarges the stream. The faster the flow, the greater is the action. A stream in flood can easily move massive boulders a great distance. Throughout the course of a river, particles are being worn away, transported, and deposited. The finer particles are transported to the lower reaches of the river, where they are deposited as *silt*. (See Rivers.)

On the coast, waves carrying sand and pebbles pound ceaselessly against the shore, cutting into and weakening the rock. (See Coasts.)

In dry regions, the wind picks up particles of dust and sand and hurls them against the rocks. This natural 'sandblasting' gradually breaks down the rock into sand and dust.



Above: Sometimes farmers plough their fields across rather than down a slope to prevent rainwater rushing downhill and washing away the soil. The furrows then check the speed of the water instead of giving it a clear channel down. This is called contour ploughing.
Left: The rate of erosion depends largely upon the hardness of the rock. Devil's Tower (Wyoming, U.S.A.) is an example of a volcanic rock tower which once formed the core of a volcano and was left standing long after the softer surrounding rocks had been worn away.

In many mountainous regions the higher ground is snow-covered all the year round. As more snow falls, the snow underneath changes to ice. Vast 'rivers of ice', or *glaciers*, form in the valleys and gradually 'flow' downwards. As they move down, they break off and collect rock fragments which grind away other rocks.

However, erosion is not just something for the geologist to worry about. Farmers worry about it, too, because fertile topsoil can be washed or blown away. To prevent this happening, farmers plough hilly land with furrows across the slope instead of up and down. This is called *contour ploughing*.

Eskimos are a Mongoloid people with yellow skins and black hair, who live along the shores of North America, eastern Siberia, and the coasts of Greenland. In these barren lands, winters are long and severe, and the summer season is brief. Numbering only about 54,000, the Eskimos depend on the hunting of arctic animals such as seals, walruses, and bears for their livelihood. They also fish and gather edible plants. Some Eskimos build winter houses of snow, called *igloos*.

There are several distinct groups of Eskimos, each with its own dialect, traditional skills, and way of life. After the European explorations of the 17th century, contact with traders and explorers changed their lives. New tools were made available to them, as well as firearms. But they also suffered from the introduction of the white man's diseases, formerly unknown because of their intensely cold and almost germ-free environment.

Eskimos have a highly developed art and are skilled carvers of bone and walrus tusks. They dress mostly in furs, use sledges pulled by dogs for transport in winter, and skin-covered canoes or kayaks in summer. They hunt in small groups and are very self-reliant and independent.

Many Eskimos have now left the old

The traditional Eskimo way of life, with its simplicity and hardships, is fast disappearing, as Western influences penetrate their Arctic homelands. Many have given up the wandering life of the hunter to work in government establishments.

tribal life and become skilled workers. In Greenland, in particular, the Eskimos (who prefer to be known as Greenlanders) have become increasingly civilized. Only a small percentage now follow the traditional way of life. Many have trained in schools to a high educational level. Some of them have taken university degrees in Denmark, or undergone specialized technical training. In North America there are special government schemes to help them, and they are often employed in radar stations and other defence works in northern Canada, Alaska and Greenland.

Espionage is the use of spies to discover secret information about a country or an organization. Spies take great risks to serve their country, particularly in wartime, when they are likely to be executed if caught.

Most spies work for an *intelligence* or *secret service*. They may be sent on some specific operation, such as killing a traitor, carrying a message, or organizing a resistance movement, or generally to find out any information that might be useful. All modern spies use the latest scientific aids. Many have radio transmitters to send coded messages. They may write messages in invisible ink or use *microdot photography* by which a whole page of writing can be concealed behind a full stop.

Many countries have *counter-espionage* organizations which guard their country's secrets, catch spies, or perhaps feed them with false information. Counter-espionage services sometimes use *double agents*, men who pretend to spy for the enemy, but are in fact loyal.

Spies are as old as history. Moses sent twelve men to spy out the land of Canaan. Delilah used her beauty to betray Samson, as did Mata Hari in the First World War to gain secrets for the Germans. Delilah was more successful than Mata Hari, who was shot by the French. Sir Francis Walsingham knew all about

Some of the equipment used by industrial spies for 'bugging'—electronic eavesdropping—and for detecting bugging devices. The large units along the back check radio frequencies for hidden transmitters and wires for devices. In front are all sorts of tape recorders, complicated transmitters, and miniature microphones.

the Spanish Armada long before it sailed. One of his agents is said to have been the dramatist Christopher Marlowe.

Perhaps the most successful of all was the Russian spy Richard Sorge. In the Second World War he was in Japan, where he discovered German plans of the invasion of the USSR. He almost certainly saved Moscow from capture. Another famous agent of that war was 'Cicero', who got himself appointed valet to the British ambassador in Turkey. He was able to photograph top-secret documents and pass them to the Germans.

A form of spying that has become common in recent years is *industrial espionage*. Some large companies employ spies to keep them informed about the technical developments being made by their competitors. For this reason, companies try to make sure that only the people directly concerned know about new projects. They may employ security officers.

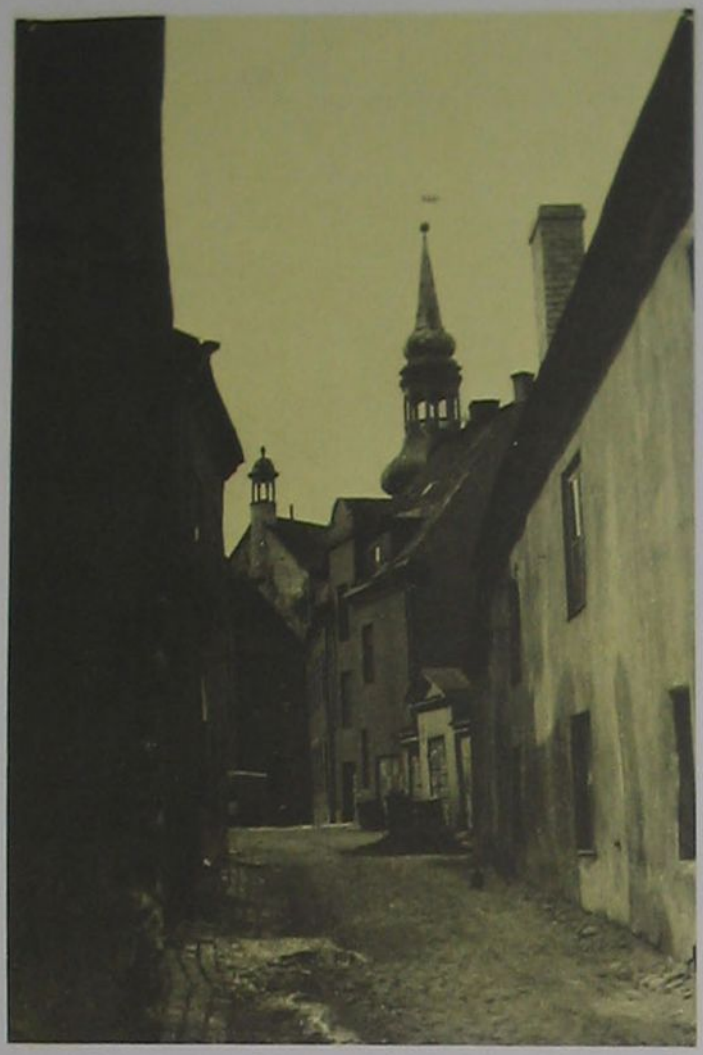
Essex, a maritime county of south-eastern England, borders on Greater London. It includes Canvey Island and Mersea Island. Its county town is Chelmsford, and its population is 1,353,500.

Essex is, for the most part, low-lying. The soil is composed of fertile clays, which accounts for the heavy crops of cereals, fruits, vegetables and sugar beet for which the county is renowned. Dairying is also important. The only forested area of note is Epping Forest, in the west. The oyster trade is centred on Colchester. Most of the huge industrial centres along the Thames estuary became part of the Greater London area in 1965. Coastal resorts include Clacton, Frinton and Southend. In 1972, Foulness, on the east coast, was chosen as the site for a new London airport.

Estonia, a land on the Baltic Sea with an area of 17,400 square miles, has been part of the USSR since 1940. From 1918 to 1940 it was an independent country. Estonia's eastern boundary is Lake Peipus, which covers some 1,200 sq. miles. Two large islands lie off the western coast. The chief city of Estonia is Tallinn, and the population is about 1,356,000.

In language and culture, the Estonians are related to the Finns. Finland lies on the other side of the Gulf of Finland.

Estonia's farmers grow potatoes, grain and flax, and raise cows, pigs and sheep. In 1948, collective farming was introduced. The country has oil and gas deposits, and extensive forests that provide timber and pulp. There are textile industries.



Above: An old street in Tallinn, capital of Estonia. Since 1940, this little Baltic country has been one of the states of the USSR. It is officially called the Estonian Soviet Socialist Republic.
Left: Location map of Estonia.

During its history Estonia has belonged to Denmark, Germany, Poland, Sweden and—from 1721 to 1918—Russia. After 22 years of independence, it was again taken by the Russians during World War II.

Ethiopia is an ancient empire in north-eastern Africa. It is a monarchy with an emperor who has supreme power. Many people in Ethiopia believe that the emperor's family is descended from the Queen of Sheba and King Solomon. Ethiopia was once called *Abyssinia.*

Apart from some hot, dry plains, in the east and south, Ethiopia is a mountainous land, with a cool, moist climate. In the mountains, the rainfall is between 20 and 80 inches a year. Through Ethiopia's mountains runs the deep African rift valley, a massive trough, which contains several lakes.

Right: A girl from the province of Harar in Ethiopia.

Most Ethiopians are farmers or cattle owners. Coffee, which grows wild and in plantations, is the most important export. Other exports include hides and skins and farm products.

Christianity was introduced into Ethiopia in the A.D. 200's. It survived despite several attacks from neighbouring Muslim states. The Christian Coptic Church is still the country's official church.

Ethiopia remained independent when most of Africa was colonized by European powers. In 1896, the Ethiopians defeated an Italian army. In 1935, the Italians again attacked and conquered Ethiopia. But British and Ethiopian troops defeated the Italians in 1941. In 1952, Eritrea, a former

Left: Location map showing the position of Ethiopia (black).

Facts and Figures
Area: 457,267 square miles.
Population: 25,000,000.
Capital: Addis Ababa.

The church at Lalibela, Ethiopia, is hewn out of the rock face. Christianity was introduced to Ethiopia in the 3rd century A.D.

Italian territory on the Red Sea, merged with Ethiopia. Since the 1950's, many nations have given financial and technical aid to Ethiopia.

Euphrates is a river that flows for 2,235 miles through south-west Asia into the Persian Gulf. It rises in Turkey and flows south-eastwards across Syria and Iraq. Eventually it forms a flat delta region with the River Tigris, which joins it for the last 113 miles. The Euphrates floods every spring, but has a system of reservoirs, dams and canals that control the waters and are used in irrigation schemes.

In ancient times, the region between the rivers Tigris and Euphrates was known as *Mesopotamia*—'the land between the two rivers'. There the great civilizations of Sumeria, Babylonia and Assyria developed. The river was a well-used trade route, and the region flourished because of irrigation works more extensive than those of today.

Europe is the smallest of the continents with the exception of Australia, but it is second only to Asia in population. One person in five lives in Europe. It is known as the birthplace of western civilization. Its art, political ideas, and scientific discoveries have spread all over the world. Among the 34 countries that make up Europe are part of the world's largest (Russia), and the smallest (Vatican City).

The continent of Europe forms the western peninsula of the great Europe/Asia land mass. Its eastern limits are the Ural Mountains, and its south-eastern boundary is the frontier between Russia and Turkey and Iran. A small part of Turkey, north-west of the Sea of Marmara, is in Europe. Everywhere else Europe is surrounded by sea. The continent has an area of 4,063,000 square miles. Its greatest length is 4,000 miles, and its greatest width 3,000 miles. It has a population of 644,849,000.

There are four main land regions. *The Alpine Mountain System* runs across southern Europe and includes the Caucasus, the Balkans, the Carpathians, the Apennines, the Alps, the Pyrenees and the Sierra Nevada. The highest peak is Mt Elbrus (18,481 ft) in southern Russia. *The Central Uplands* are densely forested, but they also contain some of Europe's most productive coalfields. The uplands run from Czechoslovakia, through southern Germany, central France, central Spain and Portugal. *The Central Plains* rarely rise more than 500 feet above sea level. They extend from the foothills of the Ural Mountains in Russia, through Poland, northern Germany, The Netherlands, Belgium, northern France and south-eastern England. Farming is the chief occupation of this broad, fertile area. *The North-West Highlands* are craggy and steep. The soil is too poor for large-scale farming. The highlands extend from northern Finland, through Sweden, Norway, northern and western Britain, Ireland and western France.

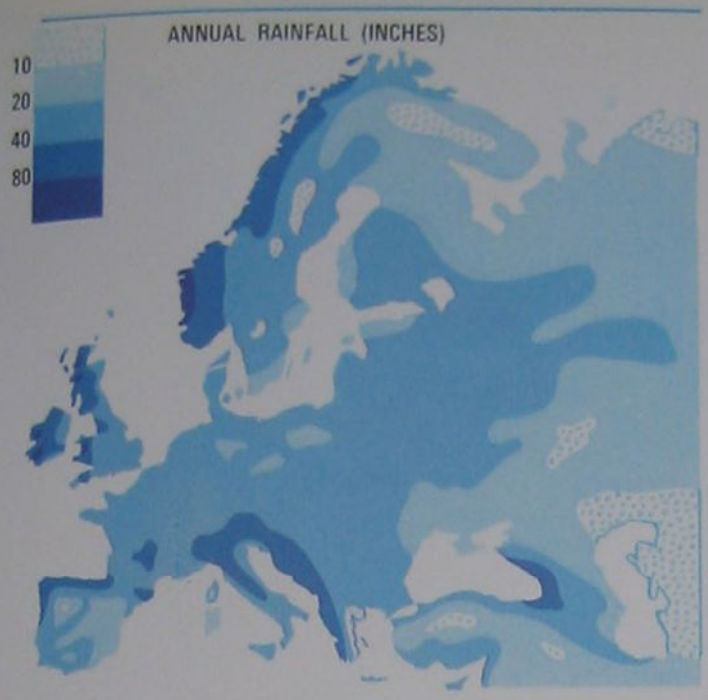
Europe is well served with rivers. Most of the main ones are used as major transport routes. The longest river in Europe is the Volga which flows through Russia for 2,290 miles before emptying into the Caspian Sea. Other important rivers are the Rhine, which flows through West Germany and The Netherlands into the North Sea; the Danube, that flows eastwards from West Germany through Austria, Hungary, Yugoslavia and Rumania to the Black Sea; the Seine, on which Paris stands; and the Thames.

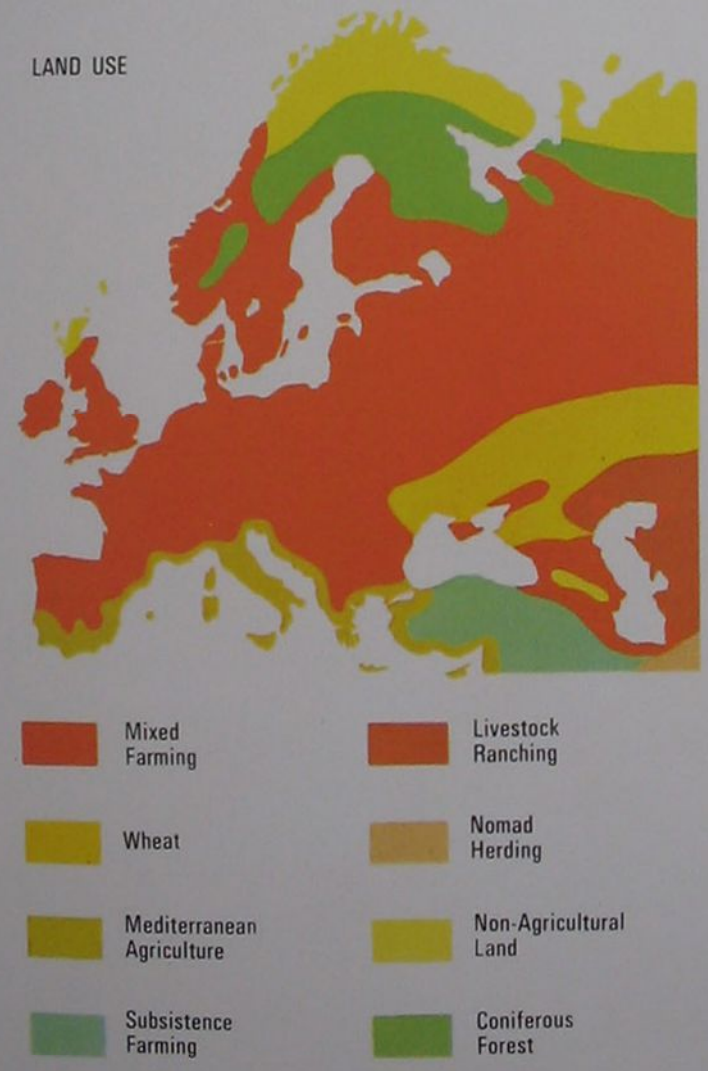
Lakes are plentiful in Europe. Finland alone has some 60,000. The largest lake in the world, the salt-water Caspian Sea, lies between Asia and Europe.

Most of Europe has a mild climate. In winter, large areas of the continent are warmed by westerly winds blowing off the Atlantic Ocean. Warm ocean currents keep most of Norway's coasts ice-free all the year round, although a third of the country lies within the Arctic Circle. In the summer, the same westerly winds keep the continent cool.

Farther south, the Mediterranean countries have mild, wet winters and hot, dry summers. Eastern Europe has colder winters and short, hot summers. The average rainfall for Europe is between 20 and 40 inches a year.

A large proportion of Europe's wild animals have been wiped out by the increasing human population and the spread of built-up areas. Survivors include





wolves, bears, wild boars, beavers, elk, foxes, hares and rabbits. The *chamois* (a species of antelope) makes its home in the Alps. Reindeer live in large herds in the northern forests. In the colder regions a number of valuable fur-bearing animals such as lynx, marten and ermine still survive. Birds are numerous, and include eagles, falcons, storks and owls.

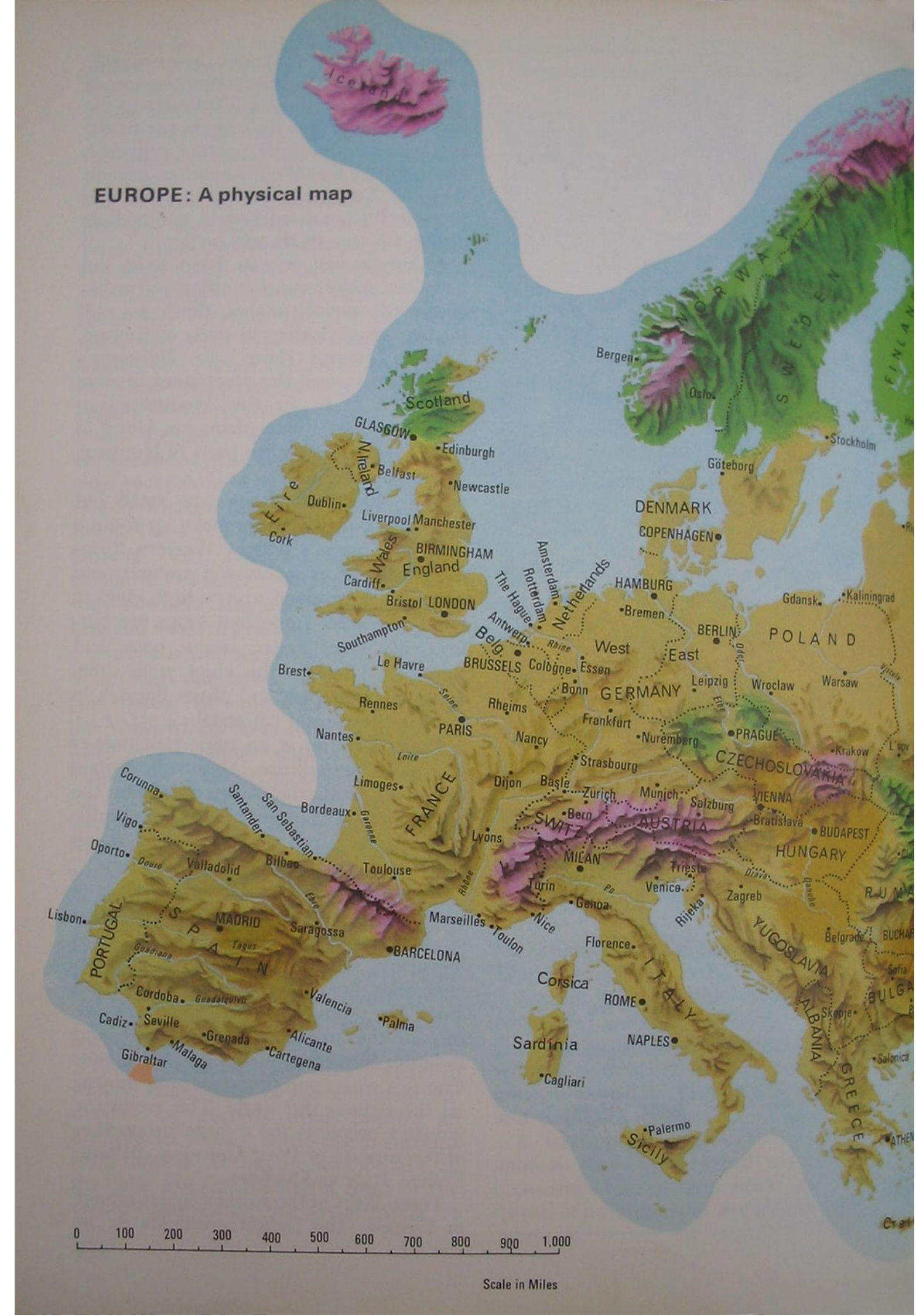
Although vast forests have been cut down to make way for cities and other man-made developments, there are still thickly forested areas in parts of Europe. Notable among these are Germany's Black Forest, and the plantations of olive and cork trees in the Mediterranean regions. Huge grassy plains are found in Russia *(steppes)*, and in parts of Hungary, Rumania and Spain.

Most European farms are small but well run. Farm workers make up about a third of Europe's people. Western European farmers use advanced methods and are able to produce a very high yield of crops per acre. Important crops are barley, oats, beet sugar, beans, peas, and tobacco. Wheat is the chief grain crop. Dates, figs, grapes, and olives flourish in the Mediterranean countries.

Dairy farming is an important part of European agriculture. Denmark, Britain and The Netherlands specialize in the production of butter, cheese, and milk. Half the exports of Denmark, Greece, Spain and Ireland consist of foodstuffs.

Europe possesses enormous centres of mining and manufacturing. The greatest of these is the Ruhr Valley, in West Germany, where vast amounts of coke, chemicals, heavy machinery and iron and steel are produced. Switzerland specializes in the production of watches, and Belgium turns out quantities of fine lace. France's wines and perfumes are renowned throughout the world. The motor-car industry accounts for a large proportion of the exports of West Germany, Britain, France, Italy and Sweden.

Three-fifths of the world's coal is mined in Europe. The richest coalfields lie in


EUROPE: A physical map
Iceland
Bergen
Oslo
Stockholm
Göteborg
NORWAY
SWEDEN
FINLAND
Scotland
GLASGOW
Edinburgh
N.Ireland
Belfast
Newcastle
Eire
Dublin
Liverpool
Manchester
Cork
DENMARK
COPENHAGEN
Wales
BIRMINGHAM
England
Cardiff
Bristol
LONDON
Amsterdam
Rotterdam
The Hague
Netherlands
HAMBURG
Gdansk
Kaliningrad
Bremen
Antwerp
Belg.
BERLIN
POLAND
Southampton
Rhine
West
East
Oder
Vistula
Brest
Le Havre
BRUSSELS
Cologne
Essen
Leipzig
Wroclaw
Warsaw
Bonn
GERMANY
Seine
Rennes
Rheims
Elbe
Frankfurt
Nuremberg
PRAGUE
Nantes
PARIS
Nancy
Krakow
Loire
Strasbourg
CZECHOSLOVAKIA
Corunna
Limoges
Dijon
Basle
Zurich
Munich
Salzburg
VIENNA
Santander
San Sebastian
Bordeaux
Garonne
FRANCE
Bern
SWITZ.
AUSTRIA
Bratislava
Vigo
Lyons
BUDAPEST
Oporto
Douro
Valladolid
Bilbao
MILAN
HUNGARY
Toulouse
Trieste
Drava
Rhône
Turin
Po
Venice
Danube
Zagreb
Lisbon
PORTUGAL
MADRID
Ebro
Genoa
Rijeka
Marseilles
Toulon
Nice
Belgrade
Saragossa
Tagus
Florence
YUGOSLAVIA
Guadiana
SPAIN
BARCELONA
Corsica
ITALY
Cordoba
Guadalquivir
Valencia
ROME
Cadiz
Seville
Palma
Skopje
ALBANIA
Grenada
Alicante
Sardinia
NAPLES
Gibraltar
Malaga
Cartegena
Salonica
GREECE
Cagliari
Palermo
Sicily
0
100
200
300
400
500
600
700
800
900
1,000
Scale in Miles

Cool Coniferous Forest
Temperate Forest
Grass
Hot Desert
Temperate Desert
Tundra Icecaps
Mountain Vegetation
60°N
40°N
0°
40°E
Murmansk
Archangel
LENINGRAD
Yaroslvl
MOSCOW
Smolensk
Kiev
Khar'kov
Dnepropetrovsk
Rostov
Odessa
ISTANBUL
Kirov
Perm
URAL MOUNTAINS
Kazan
Kuybyshev
Volga
Don
Astrakhan
Baku
U. S. S. R.

Europe has been the home of many great civilizations and its people are made up of many different nationalities, with languages and traditions of their own.

Above: The Colosseum, built by the Romans in the 1st century A.D.

Left: People still occasionally dress up in their country's traditional costume.

Britain, Russia, West Germany and Poland. The leading iron ore producers are Britain, France, Russia, West Germany and Sweden. Half of the world's iron ore is produced in Europe. *Bauxite* (aluminium ore) is mined in France, Greece, Hungary and Russia.

The people of Europe are made up of a large number of different nationalities. They each have their own ways of life, languages, literatures, customs and traditions. Today, Europe is divided into two main political camps: Western Europe and Eastern or Communist Europe.

An *iron curtain* (rigid frontier barriers) divides the rival sections. There are 9 communist countries and 25 countries of Western Europe. Trade, communications, and travel was for years hindered by this division. Relations between the two groups have recently improved.

During the present century, Europe has had to recover from two world wars, mainly fought on its soil, and a number of smaller battles. As part of the postwar recovery, 17 West European nations founded the Organization for European Economic Cooperation (OEEC) in 1948. The European Economic Community was formed in the 1950's by France, West Germany, Belgium, Italy, Luxembourg and The Netherlands, who were joined in 1973 by Denmark, Ireland, and the United Kingdom. The member countries share a parliament and a court of justice. Their eventual aim is a United States of Europe.

Talking points

*Western culture, i.e. European culture, has spread throughout most of the rest of the world. Discuss why this has come about. Remember that Europeans have colonized and emigrated to many parts of the world.

*Until the 1900's Europe was the centre of world power. In modern times the United States, Russia and China have become the dominant nations. For what reasons do you think that this has happened?

*One of the aims of the Common Market is to create a 'United States of Europe' with a central government controlling foreign and economic policy throughout the continent. Do you think that this is possible, bearing in mind the differences in language and culture that exist?

Articles to read

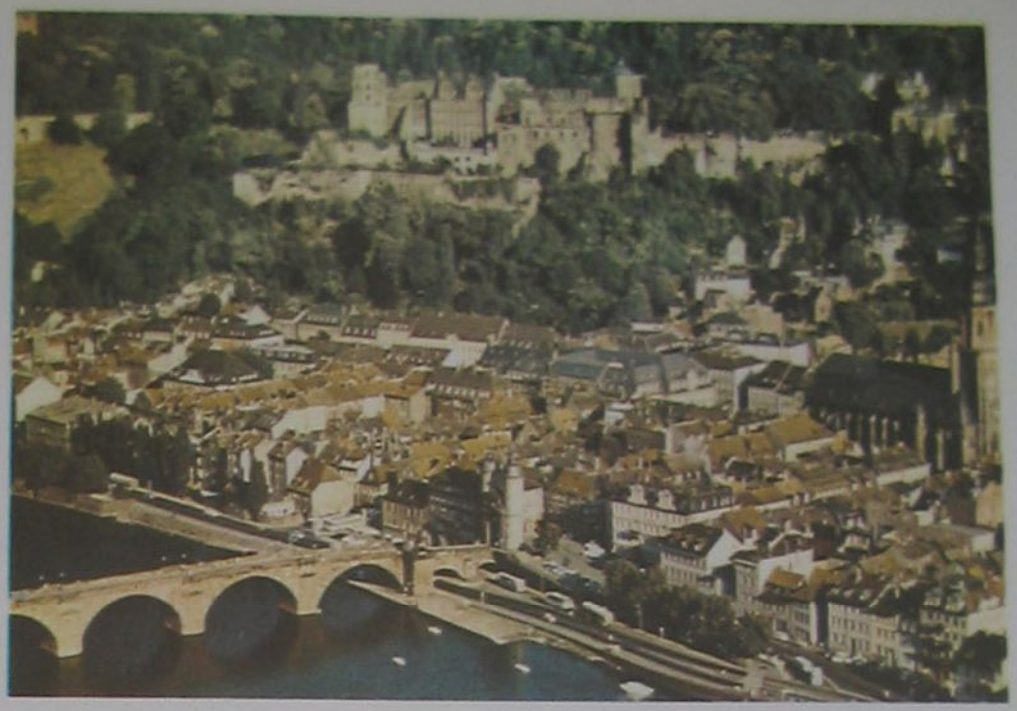
Articles on the countries of Europe; EEC.

European Economic Community (EEC)

The EEC, popularly called the Common Market, was set up by the Treaty of Rome,

Right: Europe has long been renowned as a centre of learning. Many of its towns, such as Heidelberg in Germany, are famed for their ancient universities.

Below: Europe is a small densely populated continent and most countries must export manufactured goods in order to pay for imported food. Its ports are among the busiest in the world, handling a vast amount of trade.



signed on March 25th, 1957. By its terms, the Treaty countries of Belgium, France, Italy, Luxembourg, The Netherlands and West Germany, agreed to co-operate in several economic fields for their mutual benefit. The Treaty was inspired by the success of an earlier treaty between the six countries—the European Coal and Steel Community (ECSC) which began to operate in 1952.

From 1958, the EEC countries co-operated more and more closely in many economic projects, such as the production of atomic energy. Many EEC supporters looked forward to the eventual economic, and even social and political, integration of their countries. Several other coun-

Countries of Europe

Country	*Area in sq miles*	*Population*	*Capital*
Albania	11,100	2,200,000	Tiranë
Andorra	191	19,500	Andorra la Vella
Austria	32,374	7,400,000	Vienna
Belgium	11,779	9,700,000	Brussels
Bulgaria	42,729	8,500,000	Sofia
Czechoslovakia	49,370	14,467,000	Prague
Denmark	16,619	4,900,000	Copenhagen
Finland	130,120	4,700,000	Helsinki
France	211,207	50,890,000	Paris
Germany (East)	41,815	17,076,000	Berlin (East)
Germany (West)	96,144	60,848,000	Bonn
Greece	50,944	8,736,000	Athens
Hungary	35,919	10,315,000	Budapest
Iceland	39,768	204,300	Reykjavik
Ireland, Republic of	27,135	2,900,000	Dublin
Italy	116,303	54,653,000	Rome
Liechtenstein	61	22,000	Vaduz
Luxembourg	998	339,800	Luxembourg
Malta	122	325,000	Valetta
Monaco	0·8	24,000	Monaco
Netherlands, The	15,785	13,119,000	Amsterdam
Norway	125,181	3,893,000	Oslo
Poland	120,359	33,000,000	Warsaw
Portugal	35,510	9,600,000	Lisbon
Rumania	91,699	20,300,000	Bucharest
San Marino	24	19,000	San Marino
Spain	194,884	33,609,000	Madrid
Sweden	173,666	8,093,000	Stockholm
Switzerland	15,941	6,300,000	Berne
Turkey (in Europe)	9,121	3,166,000	Ankara
United Kingdom	94,214	55,522,000	London
USSR (in Europe)	2,151,000	179,407,000	Moscow
Vatican City	0·2	1,000	–
Yugoslavia	98,766	20,600,000	Belgrade

The nine countries of the European Economic Community, the world's largest trading group.

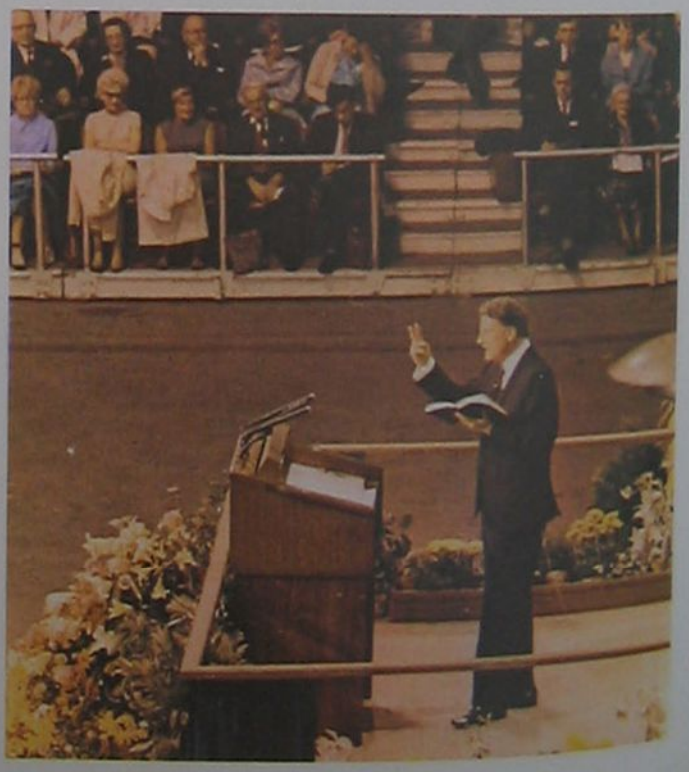
tries in Europe, Africa and Asia—particularly former French colonies—formed strong links with the EEC.

The success of the EEC soon became clear. Between 1958 and 1969, it increased the purchasing power of its workers by about three-quarters—twice as much as Britain. It was part of EEC policy gradually to lower import taxes between EEC countries and increase them on goods from other countries. Threatened with economic isolation in Europe, Britain joined Austria, Denmark, Norway, Portugal, Sweden, Switzerland, and later Finland, in the European Free Trading Area (EFTA). However, EFTA was not nearly so close-knit or strong as the EEC, nor so successful.

During the 1960's it became clear that, because of the increasing complexity of technology, several important industries were becoming too costly for any nation to maintain. Only super powers like the United States and U.S.S.R. could maintain aircraft and computer industries. However, by 1970 the EEC was on its way to becoming an economic superpower. As EEC tariffs rose, British businessmen feared that British goods would be too costly to sell to the EEC, and that to remain outside the Common Market might bring ruin to Britain. In the 1960's, both Conservative and Labour governments in Britain tried and failed to enter the EEC. Finally, Edward Heath's government took Britain into the EEC on the first day of 1973. Denmark and the Republic of Ireland—whose peoples had voted in favour—joined the EEC along with Britain. The Norwegians voted against joining, so Norway stayed outside the EEC. No vote was held in Britain. Collectively the nine EEC countries in 1973 numbered about 260 million people. Only China and India had more people. The gross national product of the EEC was more than double that of Japan, almost double that of the U.S.S.R., and about half that of the United States.

Evangelism is the belief that the gospel of Jesus Christ should be preached directly to people without any need for a highly organized and established Church and elaborate services. Many evangelists preach that men can be saved and go to heaven only as the result of their faith in God and not of the good works they do on earth. They believe that men can be suddenly converted and live new lives.

Dr Billy Graham, the famous American lay preacher, speaking to a large gathering of people in London.



All the nonconformist Churches are to some extent evangelistic. The Congregationalists, originally called Brownists, developed from the Puritans of the 1500's. They try to avoid excessive centralization: each congregation elects its own minister. They have close ties with the Presbyterians, who are strong in Scotland. The Society of Friends, better known as the Quakers, was formed by George Fox in 1647. Quakers reject formal services and sacraments such as baptism and Holy Communion. In 1791 a Unitarian society was formed. The Unitarians believe in the unity of God and reject the idea of the Trinity.

John Wesley founded the Methodist Church during the 1700's. It was a breakaway movement from the Church of England. A feature of the Methodist Church is the number of *lay* or *local preachers*, who lead services.

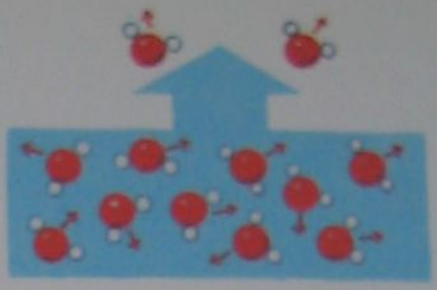
General William Booth founded the Salvation Army in 1865. The Salvation Army has always concentrated on bringing the Christian message to the poorest and neediest of people. It does much valuable social work and runs a service for tracing missing people.

Some evangelistic Churches hold *fundamentalist* views—that is, they believe that every word of the Bible is literally true.

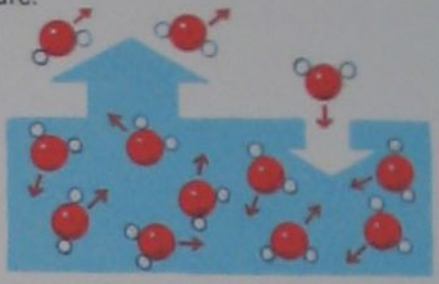
Evaporation is the process that changes a liquid into a gas. It can occur at any temperature, and is due to the movement of molecules in the liquid. For example, water left in a saucer will gradually evaporate. The water molecules escape into the air as a gas—water vapour.

The warmer the air, the more moisture it can hold in the form of vapour. Every second, about 15 million tons of moisture is evaporated from the Earth's surface by the heat of the Sun. Water evaporated from the ocean often travels hundreds of miles before falling as rain.

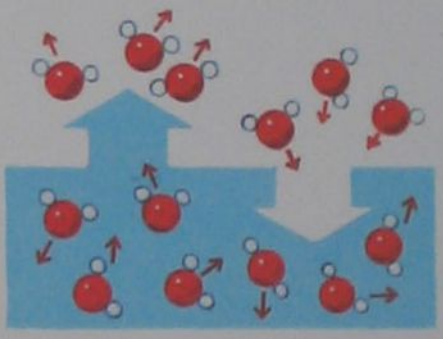
When air contains the maximum water vapour possible for its temperature, it



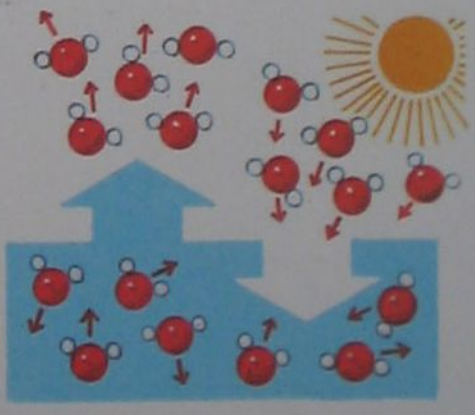
Water in its liquid state is composed of millions of molecules. Some are energetic enough to escape into the air. The number able to do so depends on the temperature.



More molecules escape as the temperature rises. Some are attracted back into the liquid.



In time as many return to the liquid as are evaporated from it. When this happens the space above the liquid is said to be saturated.



The amount of water vapour which the air space can hold before becoming saturated is entirely dependent on the temperature. At higher temperatures more water molecules are energetic enough to evaporate. So the saturation point is reached when there is more water vapour in the air space.

is said to be *saturated*. Below this temperature, called the *dew point* for a particular mass of air, the water vapour begins to *condense* into water droplets. (See Condensation.)

The amount of water vapour in the air is called its *humidity*. *Relative humidity* is the actual amount of water vapour in the air compared with the amount the air would hold if saturated. Relative humidity is usually expressed as a percentage, and in many regions is of major importance in weather reports. Humidity is very high in the tropics, particularly in coastal regions.

Everest is a mountain peak in the Himalayas. At 29,028 feet, it is the highest in the world.

The first attempt to scale Everest was made in 1922 by a party of explorers led by General Charles Bruce. Two of the party reached a height of 27,300 feet, but the summit defeated them.

The second attempt, which was made in 1924, resulted in the death of two British climbers, George Leigh Mallory and Andrew Irvine. Two other members of the party, Norton and Somervell, reached a height of 28,000 feet before being overcome by exhaustion.

Three more unsuccessful attempts were made in 1933, 1936 and 1938. Although none of these expeditions reached the summit, knowledge was gained which benefited later expeditions. By this time climbers were considering the possibility of approaching the peak from a different direction, the south-west. In 1951 a British mountaineer, Eric Shipton, led a party to reconnoitre the new and so far unattempted south-west route. In 1952 two Swiss expeditions also followed this route, but neither succeeded in reaching the summit.

Finally, in 1953, a British expedition, led by Sir John Hunt, made history by conquering the summit. The success of this attempt was due largely to the knowledge and experience gained by previous

Right: Everest is the highest mountain in the world. Its summit was first reached in the summer of 1953.

climbers using this relatively new south-west approach. In a carefully planned campaign, many camps were set up on the Arctic-like slopes, the last camp being only 1,100 feet below the summit and consisting of a single tent. From this last camp a New Zealander, Edmund Hillary (later knighted), and a tough Himalayan Sherpa mountaineer, Tenzing Norkay, set out on May 29, 1953. After many hours they finally succeeded in reaching the summit.

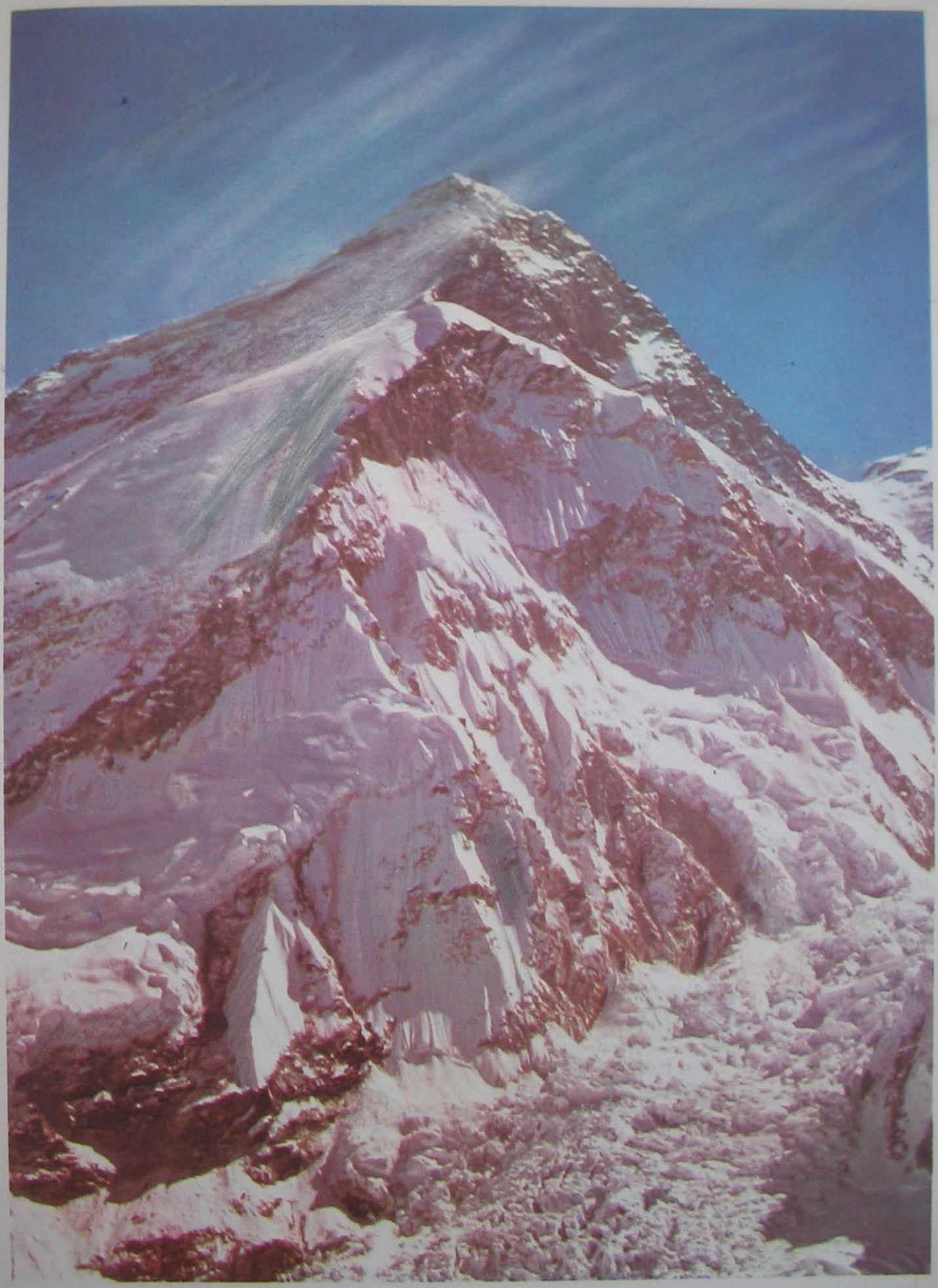
Members of a Swiss expedition led by Dr Albert Eggler again successfully scaled the summit on two consecutive days, almost exactly three years after the first successful expedition.

Everglades is a wild marshland region at the southern tip of Florida, in the south-eastern United States. It is famed for its unusual sub-tropical vegetation and the wildlife that inhabits it. Many tourists come to enjoy the beauty of the Everglades. In 1947, the United States government officially named 1,500,000 acres of it as a national park.

In parts of the Everglades there are vast areas of sawgrass prairie. This tall grass grows above the marshes, broken by occasional clumps of trees here and there. Elsewhere, the region is a huge swampland, marked by thousands of small islands or hummocks. Visitors can take motorboats through the network of waterways formed by the islands.

Many graceful waterbirds, such as herons and egrets, wade in the Everglades. Alligators glide through the swamps. Pumas, raccoons and poisonous snakes also make their home in the region.

Evergreen An evergreen is a tree or shrub that does not lose all its leaves at once, but a few at a time. Evergreens will



Some common evergreen trees, with their leaf form.

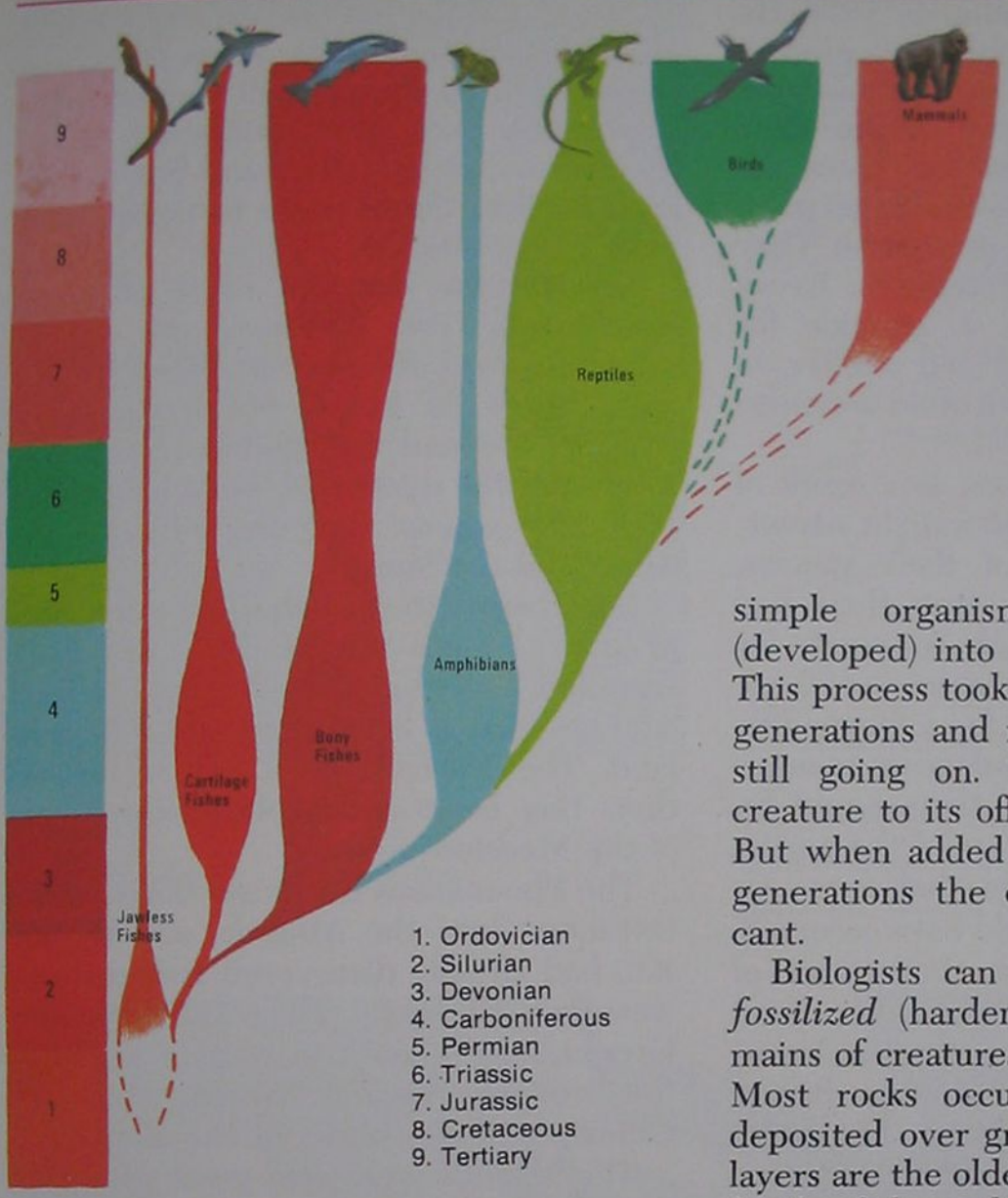
grow in almost all parts of the globe that will support vegetation. They have largely solved the problem of excessive water loss through their leaves caused by extremes of temperature. Thus, evergreens such as conifers are comfortably at home as far north as the tundra, while all tropical forests have their rich quota of huge evergreens with waxy leaves. In temperate climates, too, evergreens such as holly and laurel abound.

Plants lose water through their leaves, and evergreen leaves commonly have one or more modifications to cut down the loss of water. Conifer leaves are thin and needle shaped, exposing only a small relative surface area to the atmosphere. Temperate and tropical evergreens have leaves with a thick waxy *cuticle* (covering) on their surfaces which helps to keep water inside the plant.

Evergreens are popular in the garden because they give some colour all the year round. They make attractive hedging plants, and box trees are particularly well known in this role. They are sometimes fashioned into astonishing shapes by a clipping technique known as *topiary*. Other popular garden evergreen trees and shrubs include heather, cypress, ivy, holly, juniper, lavender, privet, rosemary, yew and rhododendron.

Evergreens are sometimes difficult to transplant. Their leaves continue to make demands upon roots recovering from the shock of transplantation. As a rule, in the Northern Hemisphere they are best transplanted in September.

Evolution means *unfolding* and *developing*. In biology, it refers to the *theory of evolution*, which explains how the great variety of living things—plants and animals—come into existence in the world. According to the theory, which is today accepted by almost all biologists,



Left: A simplified family tree of the animals with backbones, showing how each group is believed to have evolved from a common stock. The width of the vertical coloured bands represents the numbers of the various groups of vertebrates.

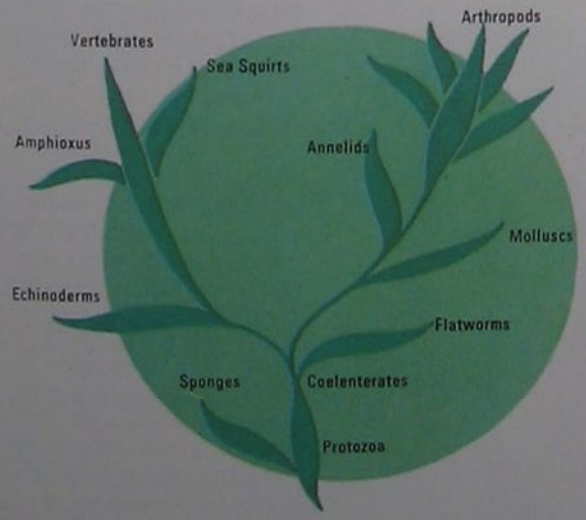
simple organisms gradually evolved (developed) into more complicated ones. This process took place over thousands of generations and millions of years, and is still going on. The change from one creature to its offspring is imperceptible. But when added together over countless generations the changes become significant.

Biologists can trace these changes in *fossilized* (hardened and preserved) remains of creatures that have been dug up. Most rocks occur in layers, and were deposited over great periods. The lowest layers are the oldest rocks and contain the fossils of the earliest creatures. This fossil record clearly shows the development of creatures through evolution over the ages.

Other evidence for evolution comes from living things. When farmers selectively breed animals to get better yields or more hardy stock, they are inducing evolutionary changes – small and accelerated ones. The differences in wild life in different parts of the world show, too, how creatures have evolved differently under different conditions. Australia, for instance, which has been cut off by sea for a long time, has quite different kinds of mammals – including pouched and egg-laying mammals – from the rest of the world.

As a result of seeing such differences on a round-the-world voyage, the British scientist Charles Darwin put forward the

Below: A possible evolutionary tree of the invertebrates. Most of the connections are merely theoretical.



modern theory of evolution in 1859. He also showed *how* evolution takes place – through a process called *natural selection*.

No two creatures, even of the same species, are precisely identical. There are tiny differences, and these tend to get passed on from generation to generation. They are inherited (see Heredity). Every creature is engaged in a 'struggle for survival'. It needs food and shelter to survive, and competes with other creatures for these necessities.

Suppose some creatures, as a result of individual differences, had a slight advantage over the others of their species. (Suppose, for instance, that they had longer necks with which to reach for food.) Then, in the long run, more of these creatures would survive for a longer life, and would pass this advantage on to more offspring. After a while, they would be virtually the only members of the particular species surviving in that area. An evolutionary change would have occurred.

Now, suppose that a similar set of creatures, with similar variations, lived somewhere else, where the natural conditions were different. (Where, perhaps a long neck was no advantage, but some other variation was.) Another, different evolutionary change would take place, and eventually two sets of the creatures would be so different as to be distinct species.

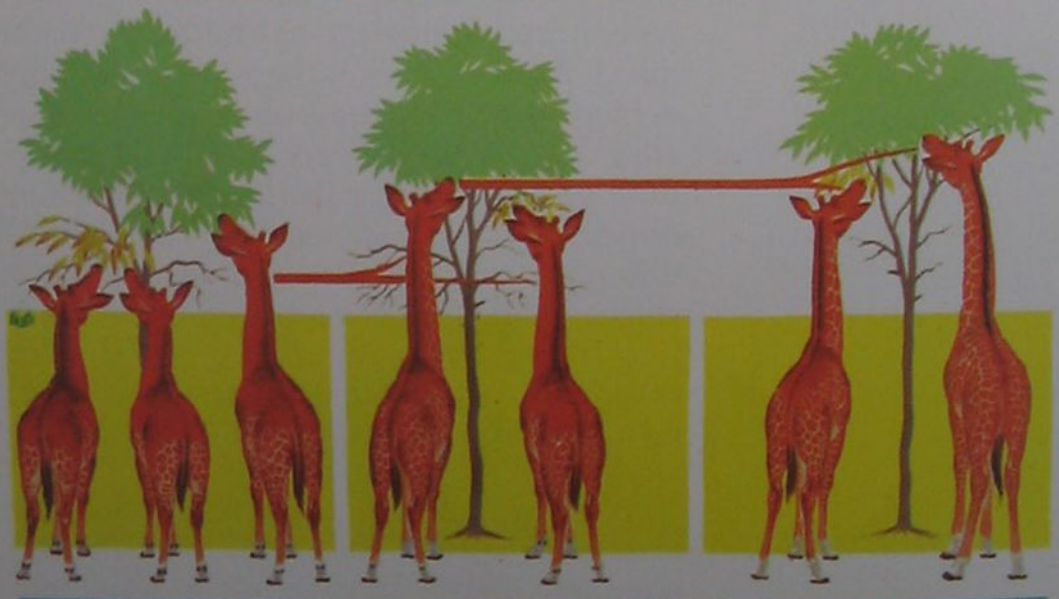
Exploration Man has always been curious about his surroundings. From the time of cavemen to the present day of space exploration men have wondered, asked themselves where? why? and how?, then tried to find the answers to these questions by exploration.

Survival was the first cause of man's wanderings. The caveman set out to search for food and shelter. When he had found these he began wondering about what lay beyond the land he could see, where did the rivers end? what lay behind the hill? where did the forests end? where did the Sun go?

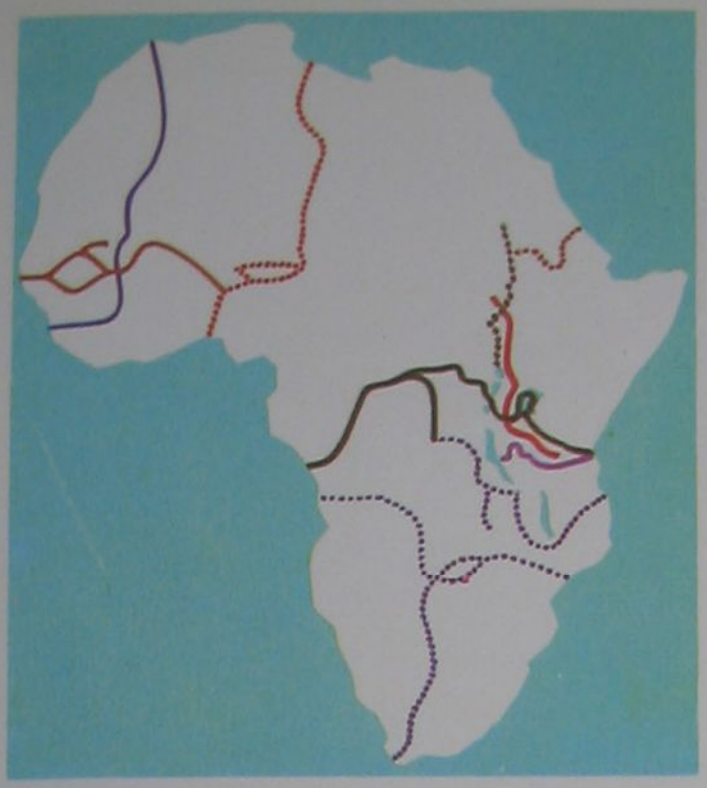
Men began to push back the frontiers of their known worlds. The Egyptians travelled widely and, as long ago as 2007 B.C., voyaged as far as the coast of Somaliland. The Minoans on Crete set sail in their tiny boats and explored the whole of the Mediterranean.

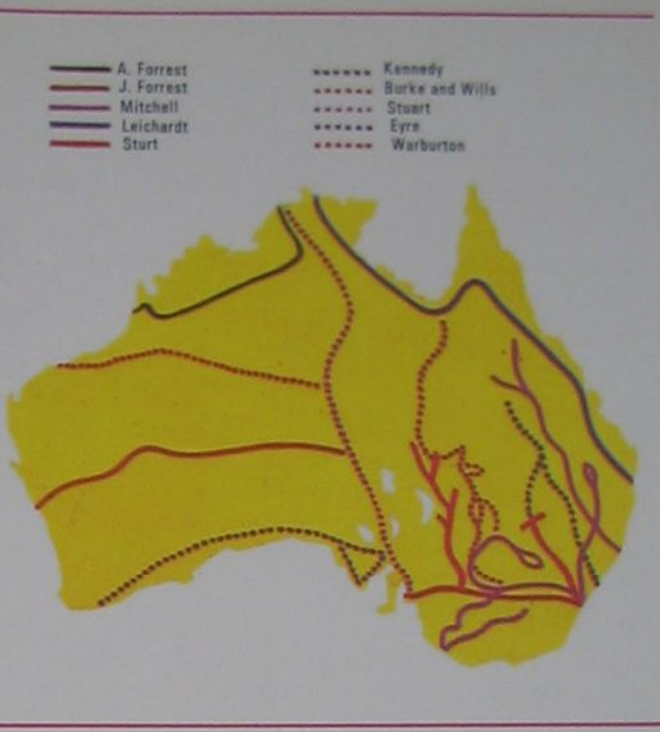
The Phoenicians broke out of the Mediterranean into the Atlantic, and by 600 B.C. had already discovered and explored western Europe. The Carthaginians, Greeks, and Romans in turn investigated the western Ancient World, while the Chinese did the same for the East.

The Vikings were also great explorers, travelling all over western Europe, far from their own lands, in small sailing vessels. They discovered and investigated Greenland and, long before the



Darwin's theory of Natural Selection can explain the evolution of the giraffe's neck. The early giraffes competed with other animals for food. The giraffes with the longest necks were able to get more food and thus survived better and produced more offspring. These too had longer necks, but some were longer than others. Selection again acted in favour of those with the longest necks until eventually the average neck length increased to its present-day size.



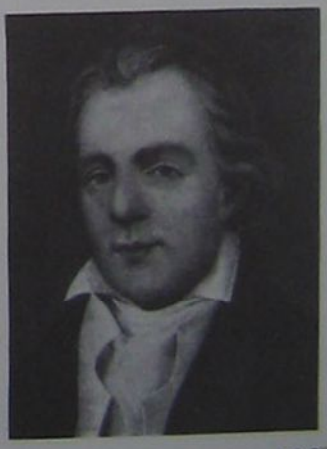


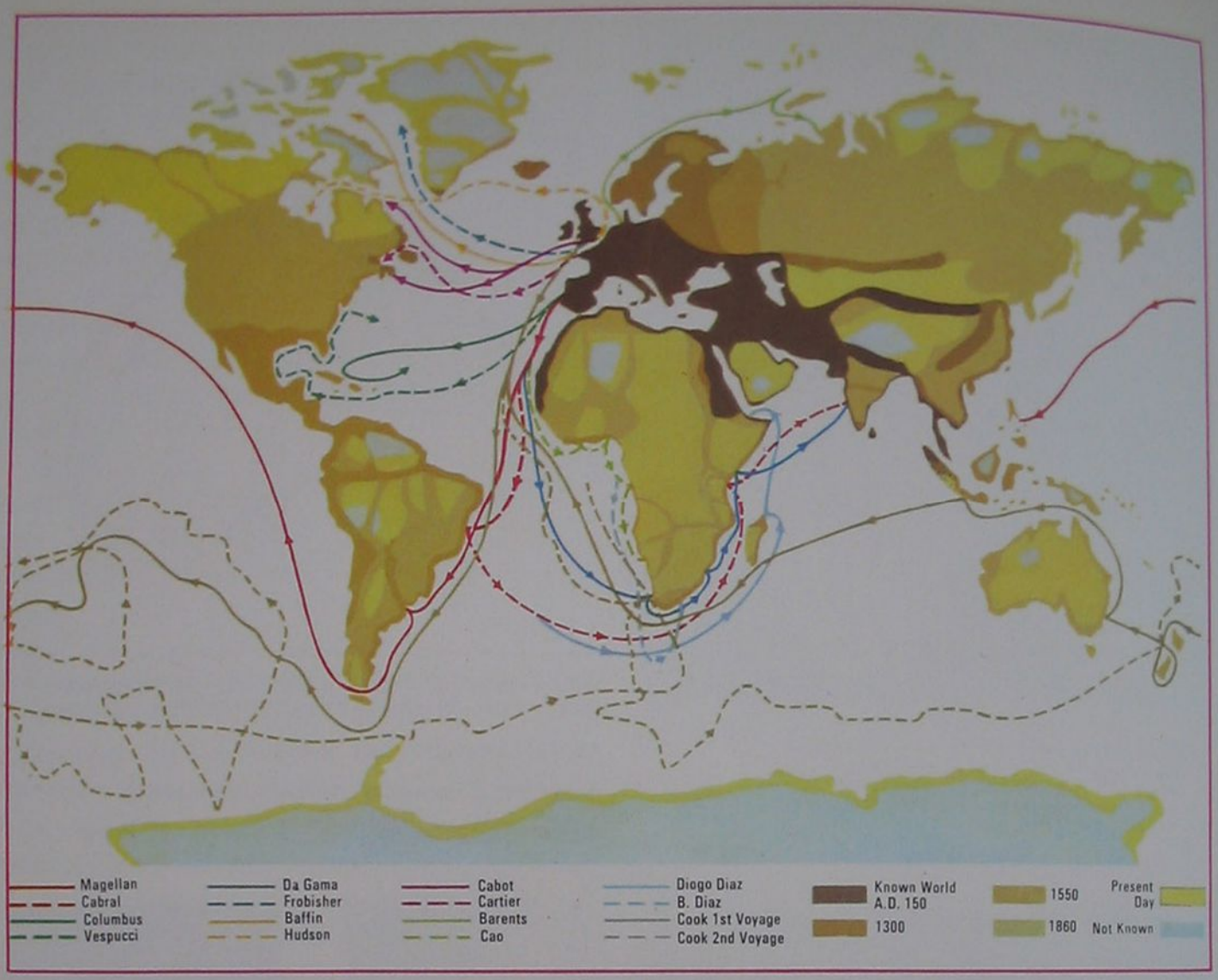
Left: Exploration map of Africa. Until comparatively recent times Africa was known as the 'dark' continent.

Above: Exploration map of Australia.

Below left: Exploration map of North America.

Below right: Amerigo Vespucci and William Clark.





Map of the world showing how it has gradually become known to man together with the routes of some of the great voyages of discovery. Some areas of the world have still not been fully explored.

time of Columbus, found America in about A.D. 1000.

For 5,000 years man investigated his immediate surroundings. In this modern age of jet-powered aircraft, nuclear power, and rocket-powered space ships, what is there left to find out? What areas of the globe still remain unknown to man?

Every part of the world has now been photographed and mapped from the air, and although there are areas of unexplored territory, these places no longer offer the same challenge to explorers as they did in an earlier age. Now, we think we know what is there, even if nobody has actually been to look. In olden days men did not know, they had to go and find out for themselves.

Today man is probing in other directions. There are projects and plans for investigating the Earth's core. Great advances are being made in undersea exploration. Scientists are studying the results of this exploration to find ways of obtaining minerals and more food from the oceans and so satisfy man's ever increasing needs.

Man's exploration of space began in 1961 when Yuri Gagarin was sent into orbit around the Earth by the USSR. In 1969, the United States first landed men on the Moon.

The greatest challenge remaining to man today is the conquest of outer space. Men are again facing unknown dangers and obstacles in their attempts at exploration – this time, the world beyond the Earth.

SOME FAMOUS EXPLORERS

AUSTRALIA, NEW ZEALAND, OCEANIA

Burke, Robert O'Hara, 1820-61, Irish: Crossed Australia from south to north.

Cook, James, 1728-1779, British: Sailed right round New Zealand; landed at point on Australia which he named New South Wales; first to cross Antarctic Circle; discovered New Caledonia, Norfolk Island, Cook or Hervey Islands, and South Georgia; explored Easter Island, the Marquesas and the Tonga Islands; rediscovered Sandwich Islands (Hawaii); surveyed both sides of the Bering Strait.

Dampier, William, 1652-1715, English: Sailed round Cape of Good Hope to Australia; landed at Shark Bay on west coast; explored as far as Dampier Archipelago.

Flinders, Matthew, 1774-1814, English: Explored entire south coast of Australia from Cape Leeuwin to Bass Strait; charted east coast of Australia and Gulf of Carpentaria.

Forrest, John, 1847-1918, Australian: Led coastal expedition from Perth to Adelaide.

Stewart, John McDouall, 1815-1856, Scottish: First to reach centre of Australia.

Sturt, Charles, 1795-1869, English: Explored river systems of south-eastern Australia; discovered Darling River.

Tasman, Abel Janszoon, 1603-1659, Dutch: Discovered Tasmania and New Zealand; explored northern coast of Australia.

AMERICAS (INCLUDES ARCTIC)

Baffin, William, 1584?-1622, English: Searched for North-West Passage and gave his name to Baffin Island and Baffin Bay.

Balboa, Vasco Núñez de, 1475-1519, Spanish: Crossed Isthmus of Panama; first European to reach eastern shore of the Pacific.

Bering, Vitus Jonassen, 1681-1741, Danish: Pioneered Russian Arctic exploration; discovered Bering Strait and Alaska.

Cabot, John, 1450-1498, Genoese: Discovered North American mainland; reached Greenland which he named Labrador.

Cabot, Sebastian, 1474-1557, Venetian: Explored Brazilian coast and the Rio de la Plata region of South America.

Cabral, Pedro Alvares, 1467-1519, Portuguese: Discovered Brazil; also found island of Madagascar on voyage round Cape of Good Hope to India.

Cartier, Jacques, 1491-1557, French: Discovered St. Lawrence River and Bay; explored Canadian coast as far as Montreal.

Columbus, Christopher, 1451-1506, Italian: Discovered America and opened up the New World for Europeans; made several expeditions to the West Indies.

Cortés, Hernando, 1485-1547, Spanish: Explored and conquered Mexico; founded settlement on Veracruz; also explored parts of California.

Drake, Sir Francis, 1540-1596, English: Sailed westwards right round the world; discovered Tierra del Fuego to be an island not a continent as previously thought; landed at California; crossed the Pacific and rounded Cape of Good Hope.

Hudson, Henry, died 1611, English: Rediscovered Hudson Bay, Strait, and River, which were named after him; searched for North-West Passage and reached Spitsbergen and Greenland.

Franklin, Sir John, 1786-1847, English: Surveyed thousands of miles of Arctic America; explored basins of Saskatchewan, Coppermine, and Mackenzie rivers.

La Salle, Robert Cavelier sieur de, 1643-1687, French: Explored the Mississippi. Was the first person to sail all the way down to its mouth. He claimed the entire valley for France.

Lewis, Meriwether, 1774-1809, American, and **Clark, William,** 1770-1838, American: Together explored much of the western half of the United States. They travelled up the Missouri for nearly 2,000 miles, crossed the Rockies and reached the Pacific.

Magellan, Ferdinand, 1480-1521, Portuguese: Led voyage around the world; discovered the strait that links the Atlantic and Pacific Oceans across the tip of South America which is now named after him; crossed Pacific to Philippines.

Nansen, Fridtjof, 1861-1930, Norwegian: Led two north-polar expeditions; crossed Greenland from east to west for the first time; made first crossing on skis of the Greenland ice-cap.

Nordenskiöld, Adolf Eric, 1832-1901, Finnish-Swedish: First man to sail through the North-East Passage; penetrated far onto inland ice of west Greenland.

Orellana, Francisco de, 1511-1546, Spanish: First explorer of the Amazon River which he named, reached Atlantic coast.

Peary, Robert Edwin, 1856-1920, American: First man to reach the North Pole; crossed Greenland by sledge; proved that Greenland is an island.

Soto, Hernando de, 1496?-1542?, Spanish: Widely explored south-eastern part of United States; discovered the Mississippi River.

Vespucci, Amerigo, 1454-1512, Florentine: Claimed to have discovered America, which was named after him (this proved to be untrue); voyaged several times to the New World and thoroughly explored north-west coast of South America.

ANTARCTICA

Amundsen, Roald, 1872-1928, Norwegian: Discovered the South Pole; also led expedition in Arctic through North-West Passage; flew in airship across the North Pole.

Byrd, Richard Evelyn, 1888-1957, American: Led several expeditions to Antarctica; also explored Arctic; first man to fly over both the North and South Poles.

Scott, Robert Falcon, 1869-1912, British: Explored Antarctica and pioneered a route to the South Pole.

Shackleton, Sir Ernest Henry, 1874-1922, British: Pioneered route up the Beardmore Glacier to the South Pole; led several Antarctic expeditions.

ASIA

Da Gama, Vasco, 1469-1524, Portuguese: First man to sail round Cape of Good Hope to India; arrived at Calicut; explored Malabar coast as far as Cochin; visited part of Africa which he named Natal; founded Portuguese colony at Mozambique in Africa.

Polo, Marco, 1254?-1324?, Venetian: Took part in one of the longest land voyages of the Middle Ages; crossed Persia, western Asia, and the Gobi Desert to Peking; also travelled extensively in the eastern Mediterranean and visited Constantinople (Istanbul); journeyed in both China and India.

AFRICA

Baker, Sir Samuel, 1821-1893, English: Explored African interior; discovered and named Lake Albert Nyanza.

Bruce, James, 1730-1794, Scottish: Discovered source of the Blue Nile in Abyssinia (now Ethiopia).

Burton, Sir Richard Francis, 1821-1890, British: Explored source of the Nile, discovered Lake Tanganyika; explored Gold Coast; in America, crossed the Andes from both directions, canoed down São Francisco River, explored Río de la Plata and the Amazon; also made pilgrimage from Mecca to Medina.

Clapperton, Hugh, 1788-1827, Scottish: First European to explore Northern and Central Africa; crossed River Niger.

Diaz, Bartholomew, 1457-1500, Portuguese: Explored west coast of Africa and discovered Cape of Good Hope.

Lander, Richard Lemon, 1804-1834, British: Discovered Benue River; found source of Nile and the delta of the Niger.

Livingstone, David, 1813-1873, Scottish: First white man to travel the length of Lake Tanganyika; discovered Victoria Falls on the Zambezi; explored unknown Central Africa.

Park, Mungo, 1771-1794, Scottish: Explored African interior; discovered the River Niger.

Speke, John Hanning, 1827-1864, English: Found Nile source, discovered and named Lake Victoria; first European to visit Uganda; marked exit of Nile from lake by naming Ripon Falls.

Stanley, Sir Henry Morton, 1841-1904, Welsh: Led expedition to African interior to search for David Livingstone; explored Lake Tanganyika; traced Congo River from source to mouth; founded Congo Free State.

Explosives Since the Chinese invented gunpowder, the earliest explosive, in about A.D. 1000, wars have become increasingly destructive. Cannons, muskets, rifles, artillery, mines and bombs have taken their toll of human life. But on the other hand, explosives have also been a boon. They have helped us 'move mountains' in all kinds of engineering projects, particularly the building of canals, roads and tunnels. Mining would be desperately slow without them, too.

Gunpowder, which is a mixture of saltpetre, sulphur and charcoal, is not very powerful. It is often called a *low explosive*. It could be said that gunpowder burns rapidly rather than explodes. This makes it more suitable for fireworks than for bombs.

The most powerful explosives are nuclear explosives in which splitting atoms in atomic bombs and fusing atoms in hydrogen bombs produce vast amounts of energy. Above: A nuclear test explosion at Bikini Atoll.

Dynamite is by far the most widely used blasting explosive. It contains a sensitive and powerful high explosive called *nitroglycerine*, a heavy, oily liquid.

The Swedish chemist Alfred Nobel produced the first dynamite in 1867. He found that a kind of earth called *kieselguhr* would absorb a lot of nitroglycerine. The explosive produced is still powerful but less sensitive to shock than pure nitroglycerine. It needs a powerful shock from a *detonator* to set it off and is therefore safe to handle normally. *Gelignite* is another form of dynamite.

Trinitrotoluene (TNT) is the main high-explosive ingredient of shells and bombs.

All of the explosives mentioned so far are *chemical* ones. The most powerful explosives of all – the atomic and hydrogen bombs – are *nuclear* explosives (see Nuclear energy).

Extinct animals There are many reasons why certain animals have become extinct. One important reason is *evolution*, the gradual change in living forms that takes place over millions of years. As newer animals evolved which were better adapted to their living conditions, many of the older types slowly died out because they could not compete successfully for food and other essentials. Scientists have to depend upon bones and fossils for their information about the older extinct animals.

The ancestors of some present-day

The dodo, a relation of the pigeon which lived in Mauritius, was killed by European seamen for food. It became extinct in the 1680's.

animals became extinct in prehistoric times. The mastodon and mammoth, predecessors of the modern elephant, lived during the Ice Age. These animals had trunks like the elephant, but their tusks were long and curving and thick hair covered their bodies. Early Man was probably familiar with them.

Sometimes animals die out because of relatively sudden changes in their environments that leave them unable to fend for themselves. Dinosaurs dominated the Earth during the Mesozoic Era, 225 to 65 million years ago. Then their swamps drained, the climate became colder and the plant-eating dinosaurs became prey to meat-eating species. (See Prehistoric Animals.)

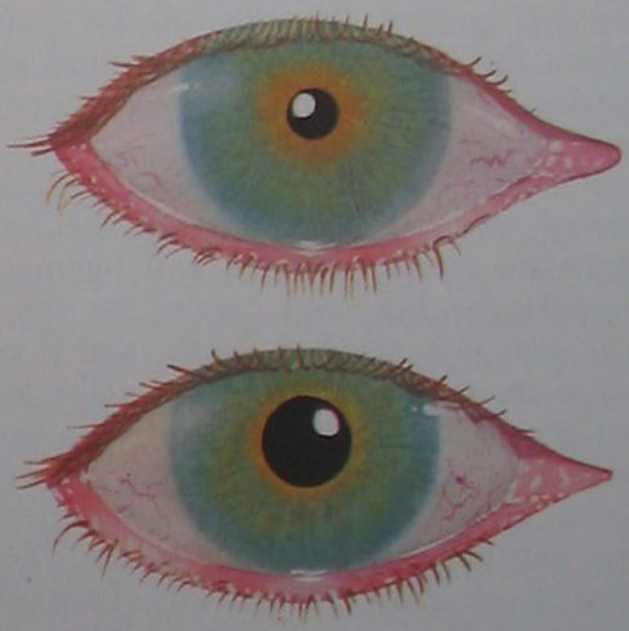
Some animals have become extinct only recently, largely because of Man's activities. Not only has Man hunted indiscriminately, but he has also destroyed animal food supplies and breeding grounds. The great auk, the dodo, and the moa are three different kinds of birds that men have hunted to extinction in various parts of the world.

Conservationists have campaigned for laws to protect animals, and for wild-life sanctuaries to save endangered species. But their efforts have sometimes come too late. Once there were millions of Passenger pigeons in North America. But they were finally reduced to a lone survivor in a zoo, and this bird died in 1914.

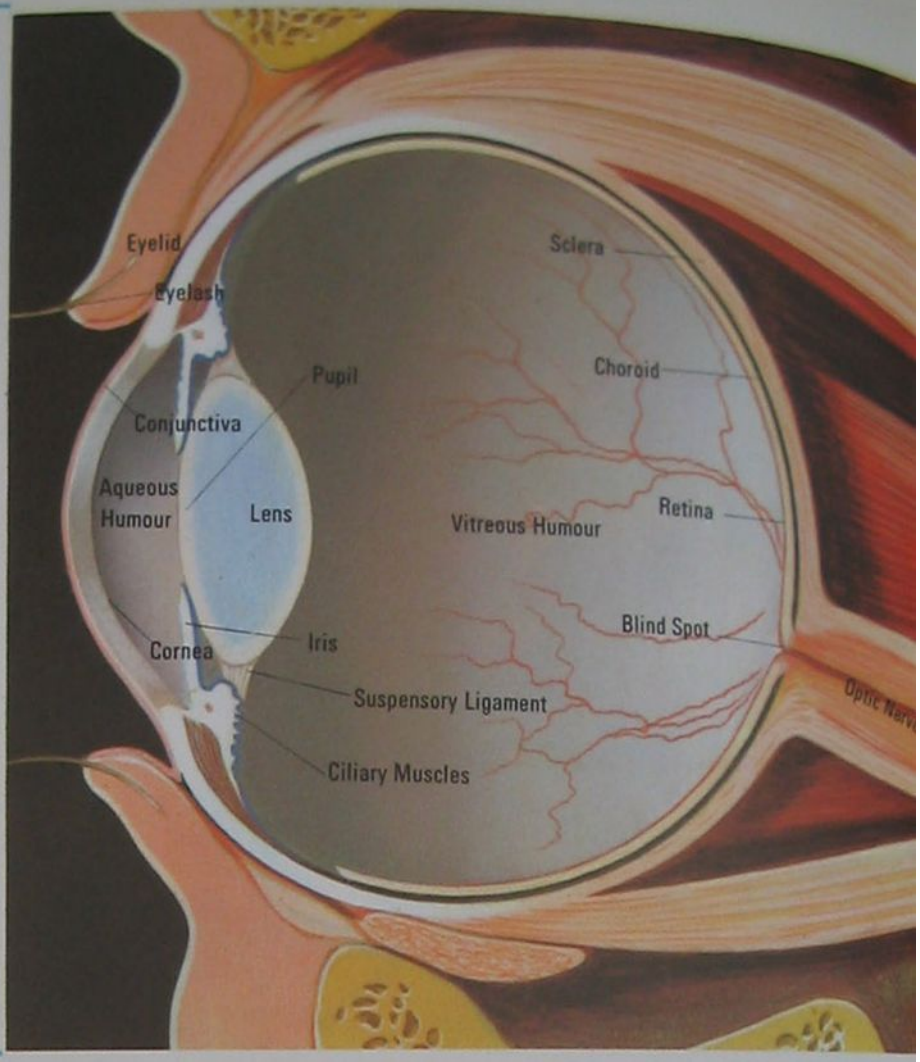
Eye This is our most important sense organ. Our eyes are delicate and sensitive, and give us detailed and accurate information about our surroundings.

The eye consists basically of a hollow ball filled with liquid. The wall of the eyeball consists of three main layers. The tough outer layer—the *sclera*—is what we see as the 'white' of the eye. Inside this is the *choroid*, which contains colouring matter. The coloured *iris* at the front of the eye is part of the choroid. The innermost layer, the *retina*, is sensitive to light. It has thousands of tiny nerve endings. When light falls on these, they send signals to the brain along the *optic nerve*. The brain translates these signals into pictures.

At the front of the eye, the sclera is transparent, and is called the *cornea*. A transparent film called the *conjunctiva*



The pupil of the eye varies in size according to the amount of light striking the retina. Top: In bright light, the pupil narrows to prevent too much light falling on the retina. Above: In dim light, the pupil opens wide to admit as much light as possible.



Above: Birds of prey such as the owl have both eyes at the front to give them binocular vision. Right: The human eye.

forms a protective layer over the cornea. At the centre of the coloured iris is an opening called the *pupil*. This allows light to enter the eye. Tiny muscles in the iris control the size of the pupil. When the light is strong, the pupil gets smaller. When the light is weak, it opens wide.

Beneath the iris is the *lens*, a transparent structure that focuses the light onto the retina. Muscles and ligaments support the lens and control its shape. The lens is somewhat elastic, and it can bulge in and out. This enables the lens to focus onto the retina light rays from both near and distant objects at different times. If the lens cannot focus all objects, the person has to wear spectacles. These consist of glass lenses that help the lenses of the eyes. If a person can see clearly only objects near to him, this is called *short sightedness*. If he can focus only objects a long way away, it is called *long* or *far sightedness*.

In the retina there are two kinds of light-sensitive cells, *rods* and *cones*. Cones, which are clustered together near the middle of the retina, enable us to distinguish the colour of objects, but they are not very sensitive and work only in good light. Rods, which are evenly spread over the retina, are much more sensitive but cannot distinguish colour. For this reason, in dim lighting we can see objects only in black and white. Where the optic nerve leaves the retina there are no rods or cones. This point is called the *blind spot*, because light falling onto it is not sensed.

Man and some other animals have *binocular* (two-eyed) vision. Because the eyes are about two inches apart, they each see an object from a slightly different angle. And each eye swivels slightly as it focuses on an object. These two factors enable us to see objects in depth and to judge their distance. Animals with their eyes at the sides of their heads, such as

cattle, cannot see the same object with both eyes, and do not see things in depth.

Eyre, Edward John (1815-1901), was a British explorer and colonial administrator. He emigrated to Australia at the age of 18, and between 1836 and 1840 made limited but valuable explorations. In 1840 and 1841, he led a disastrous expedition that endeavoured to open up a route between South Australia and Western Australia. He described his adventures in *Expeditions of Discovery into Central Australia* (1845). Places in Australia named after him include the Eyre Peninsula, Lake Eyre and the modern Eyre Highway.

In 1846, Eyre was appointed governor of New Zealand. He moved to St. Vincent in 1854, and to Jamaica in 1861. But in 1866 he was recalled to England because of his brutal handling of a Negro rising.

Eyre, Lake, is a shallow, salty lake in central South Australia. It is fed by several rivers, but is rarely filled except after the rainy season. Even then it has only reached a full depth of 7 to 13 feet twice in the last hundred years. The lake was discovered by the explorer Edward John Eyre in 1840. It has two sections, the northern being about 90 miles by 40 miles, and the southern about 38 miles by 16 miles. The total area is 2,970 sq. miles.

F

Fables are very short tales which contain some moral teaching. The characters are usually animals, but men may also take part in the action.

Aesop's Fables are the earliest and best known. Aesop was a slave in Samos (a Greek island) in the 6th century B.C., who was famed as a storyteller. After his death, collections of his stories were made. And because of his fame, he was credited with the authorship of a great many fables whose real authors were unknown.

The Chimaera was a legendary fire-breathing monster. The story probably originated from goats, lions and snakes which lived around active volcanoes.

The characters of fable are familiar to many people. Animals like the lazy grasshopper and the industrious ant show us the dangers of idleness and thoughtlessness, and the importance of hard work and common sense.

Fabulous creatures are strange and impossible animals which have never actually existed, but have been described in legends or in early works on natural history.

Some fabulous beasts combined the features of two or more real animals, while others were a blend of animal and man. The *mermaid*, for example, was said to be half woman and half fish – the upper half a pretty girl, and the lower half a large, graceful tail. Fishermen have been telling tales of mermaids for centuries, and some people still take them seriously.

Few of the other legendary creatures were so charming. They tended to be monstrous-looking and extremely fierce. The *Chimaera*, a beast described by ancient Greek storytellers, was a combination of lion, goat and dragon. The

Chimaera had a daughter called the *Sphinx*, who had a woman's head and a lion's body. She lay near the roadside, asking each passer-by to solve a riddle. Anyone who could not give her the correct answer was devoured instantly.

The Roman naturalist Pliny gave the particulars of another horrid beast, the *basilisk*. Also called the *cockatrice*, this animal was the 'king of serpents'. One glance from his evil eyes was supposed to cause instant death. Pliny said of him: 'He kills the shrubs, not only by contact, but by breathing on them, such power of evil is there in him.'

Perhaps the best known of legendary animals is the *unicorn*, which looked like a horse with a single horn on its forehead. The horn was supposed to have magical properties, so unicorns were much sought after. According to legend, however, a unicorn could never be captured by force, but only if it came willingly to rest its head in the lap of an innocent young girl.

Fairies were believed to be a race of beings, not quite human, but looking much like people in miniature. They appear in the folk-tales of many countries, and were said to inhabit magical regions on or under the Earth.

Fairies could bring good luck or bad. They had magic powers, and country people feared them. It was said that they sometimes stole human babies, leaving their own ugly children in the cradle; and that any person who wandered accidentally into fairyland either returned witless, or was never seen again. It was considered dangerous to speak of fairies by name, and so they were called 'the little people' or 'the gentle people'. Those that were not bad-natured were certainly mischievous. And although it was believed that a human might even marry a fairy, people generally considered it safest to beware of them.

The Gorgons were among the most terrifying of fabulous creatures. They had writhing serpents for hair and their faces were so terrible that any man who saw them was turned to stone. The Greek hero, Perseus, killed one of them, Medusa, and gave the head to the goddess Athene.

Opposite: The unicorn is perhaps the most famous of all fabulous animals. One is shown on this beautiful French tapestry, one of a series known as *La Dame à la Licorne*—The Lady with the Unicorn.

The first great collection of folk-tales about fairies was made up by the brothers Grimm in the early 1800's. They wrote down traditional German stories, making few alterations. Other authors did not stay so close to the original material. The French author Charles Perrault, writing more than a century before the brothers Grimm, had adapted well-known tales to suit the customs and manners of France in his day. Perrault's version of 'Cinderella' is more popular than the strictly traditional one. Some of the best-loved fairy tales were written by Hans Christian Andersen, whose stories were entirely his own creation.

The fairies in modern stories have changed considerably from those our ancestors believed in. Today the 'Bad Fairy' is an exception, and children are led to think more of 'Fairy Godmothers' and other 'Good Fairies'.

Fairs are places where people congregate for purposes of entertainment or trade. *Fun fairs* (called *carnivals* in America and parts of Europe) usually have merry-go-rounds, swings, side-shows and games. *Trade fairs* display products to the public or to trade buyers.

In Britain, markets mentioned in the *Domesday Book* can be regarded as the ancestors of the fairs that sprang up later in such places as Nottingham, Sturbridge, Oxford, St. Ives and Winchester. Bartholomew Fair in London was one of the most famous in the world during the 1400's. At this time, fairs became more specialized. Sturbridge fair sold mainly cloth and fish. Horncastle in Lincolnshire sold horses.

Entertainments helped to meet expenses. They became more popular after the introduction of hand-worked merry-

Above: When the Thames froze over in 1683, a great fair was held on its ice. Left: The Atomium, built for the Brussels international exhibition of 1958.

go-rounds in the 1600's and the use of steam power and traction engines in the 1800's.

During the 1900's there has been a resurgence of world fairs or *expositions* (formerly referred to as *exhibitions*). The famous Crystal Palace exhibition in London in 1851 was a tribute to British technical progress and set the trend for many industrial displays throughout Europe. It was commemorated in 1951 by the Festival of Britain.

The Frankfurt Book Fair is held every year in September. Publishers and booksellers exhibit current and future publications and exchange ideas. More than 50 million people from all over the world visited the vast 'Expo 67' in Montreal between April and October 1967. The frequency and organization of international exhibitions were determined in

1928 when 35 countries signed a diplomatic agreement.

Falkland Islands, along with a number of dependent islands, are a British colony. Argentina also claims them, calling them *Las Islas Malvinas*. The Falklands lie about 300 miles off Argentina's southern coast in the Atlantic Ocean. Their total area is 4,700 square miles. Only two of the 200 or so islands are large. These are East and West Falkland. Stanley, on East Falkland, is the main town and port. The land surface consists of rock-strewn moors. The weather is cool and very windy. Most of the 2,100 inhabitants are of British descent. The main industries are sheep breeding and whaling.

Family is a group of related people living together. It usually consists of a mother, a father and their children, the so-called *nuclear family*. In the past it was common for several generations to share one household, and this custom continues in some countries today. Grandparents, aunts, uncles, cousins and relatives by marriage make up the family group known as the *extended family* or *joint family*.

A person who marries is actually part of two families, his parents' family (called his *family of orientation*) and the family that consists of himself, his wife and his children (called his *family of procreation*).

In most countries today, the family is organized along *patriarchal* lines. This means that family descent is traced through the father, and that the father is the legal head of the family. *Matriarchal* organization (descent traced through the mother's side) exists today in some American Indian tribes, and may have been more common in the past.

Family life differs in each country and at each period of history. But the family has existed in every culture and in every age. Children come into the world as members of a family, and the family cares for them in infancy and childhood. Sometimes the family provides education as well, but today education is usually a

This picture of a family of the 1800's shows several generations. Until modern times families were usually large, and kept closely in touch with one another.

service supplied by the state. By joint effort, the family is usually able to provide for its members' material needs—food, clothing, shelter and recreation. In societies that live by farming, large families are better than small ones, there are more people to share the work.

Since the Industrial Revolution, the family's place in life has changed in Western countries because fathers (and, often, mothers) work away from home, and children spend a large part of the day at school. In the communal Kibbutzim of Israel children live in nurseries and are cared for by professional staff.

Talking points

*In modern industrialized societies, most families are of the nuclear type. In more primitive, agricultural societies they are often of the extended type. Why do you think that this is so?

*Discuss how family life has changed through the ages.

*The function of the family is the procreation, protection and education of children. In some countries, the last two functions can be performed by the state. What advantages do you think this system has?

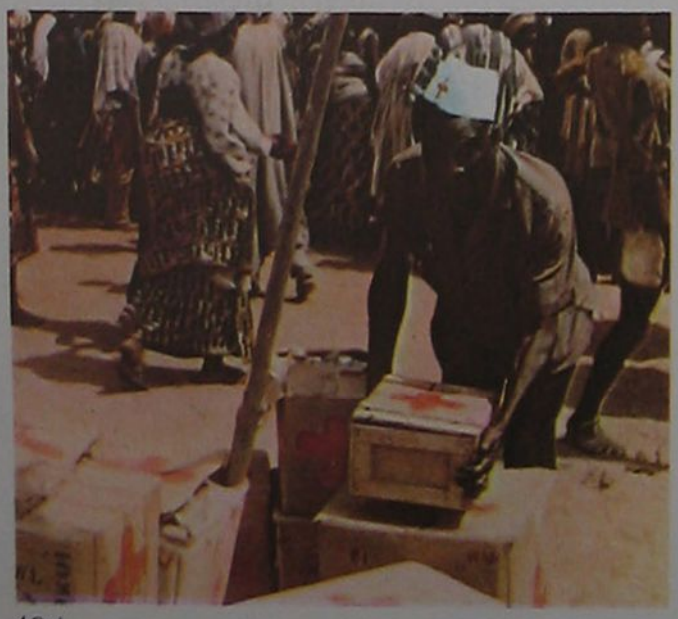
Articles to read

Education; Heredity; Marriage Ceremonies.

Famine occurs when food supplies become extremely scarce and people begin to starve to death. Famine is usually caused by natural disasters, such as drought or flood, or by sudden plagues of insect pests such as locusts, or by sudden epidemics of animal or plant diseases. But war may also bring about famine, when the fighting prevents farming or stops supplies of food from reaching a region.

Famine is less common nowadays than in former years, because the transport of food is easier now. In earlier times, people often starved because food could not reach them from nearby regions where the crops had not failed. In addition, farming techniques have improved and failure of crops is less likely to happen nowadays. But famine is still liable to occur, particularly in under-developed countries in Asia where the population has grown faster than the production of food, and where droughts and typhoons are common. There is an overall need to produce more food in the world.

Famine relief is an important part of the work of the International Red Cross organization, which transports and distributes food in famine-stricken areas.

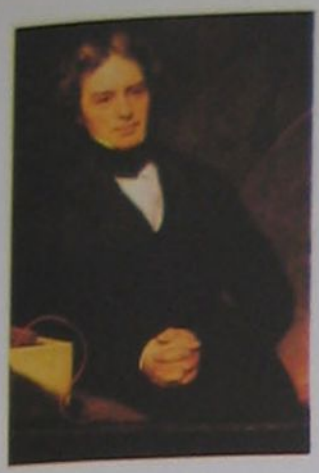


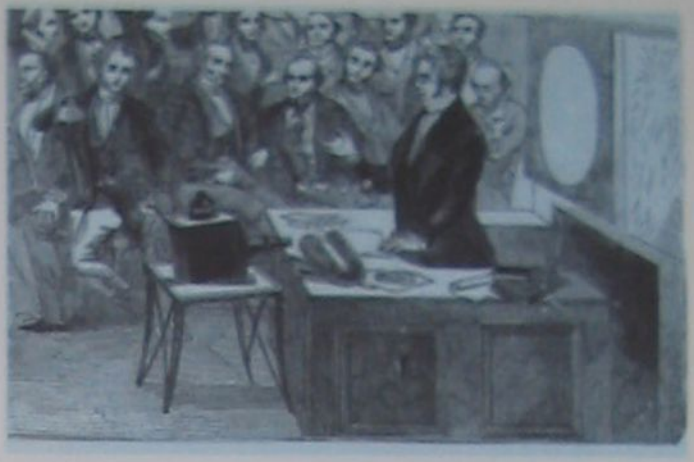
Faraday, Michael (1791-1867) was a famous chemist and experimenter whose researches laid the basis of electrochemistry and of modern atomic and electronic science. Faraday, the son of a blacksmith, as a youth was employed by a bookbinder, and his scientific interest was stimulated by studying the books that he delivered to his master's customers. He wrote a report of a lecture delivered by Sir Humphry Davy at the Royal Institution, and when this was seen by Davy, he appointed Faraday his assistant at a salary of 25s. per week.

Faraday's brilliance was soon recognised and he later became lecturer and then director of the laboratory. After Davy's death, Faraday succeeded him as Professor of Chemistry at the Royal Institution.

Among Faraday's successes was the liquefaction of chlorine, but his greatest achievements were in the realm of electricity and magnetism; his discovery of electromagnetic induction, which is the principle of the dynamo, being the most important.

Faraday made important discoveries in electrochemistry. He discovered the laws that govern electrolysis, known as Faraday's Laws, and introduced the terms now used in this field. He also found





Left: A portrait of Michael Faraday, who made several important discoveries about the effects of electricity. Right: One of Faraday's discoveries, named the Faraday effect after him, was that the plane of polarization of light is rotated by a magnetic field. He demonstrated this effect before an audience of distinguished scientists at the Royal Society, in 1846.

that a magnetic field rotates the plane of polarization of light. This effect is used in ultra-high-speed camera shutters. Faraday also found that some substances are repelled by magnetic fields. He called this effect *diamagnetism.* Faraday first conceived the idea of magnetic lines of force.

Farming takes up about three-tenths of the world's land. One-tenth is devoted to growing crops and two-tenths is used to feed livestock. Men occupy only a small fraction of the land. The remainder is almost all forests, or mountains, deserts, and other waste land.

Farmers grow many kinds of crops, both as food and to provide some raw materials from which useful products can be made. The most important food crops are the cereal crops—rice, wheat, maize, etc. Cereals grow in all regions of the world except polar regions. Sugar is another important crop. Sugar cane grows in hot

Farms near Charlottetown on Prince Edward Island, Canada. The surrounding fields are a patchwork of different crops, and are not separated by hedges.

Farming is still a primitive business in some places.

regions and sugar beet in the temperate zones. Fruits such as citrus fruits and dates, figs and olives flourish in lands around the Mediterranean Sea, and in the warm parts of America. Vegetables, especially potatoes, are grown as crops in temperate regions, and coffee, cocoa and tea are farmed in tropical areas. Animal foodstuffs, such as grass and clover, are grown by some farmers to feed their livestock.

But some crops are useful in other ways. Fibre crops, such as cotton and flax, are used to make such products as cloth, carpets, rope and paper. The oil that is obtained from the seeds of such plants as sunflowers and some nuts and palms is used in cooking and making paints. Rubber trees are an important crop in Asia and tobacco is farmed in the Americas and Asia.

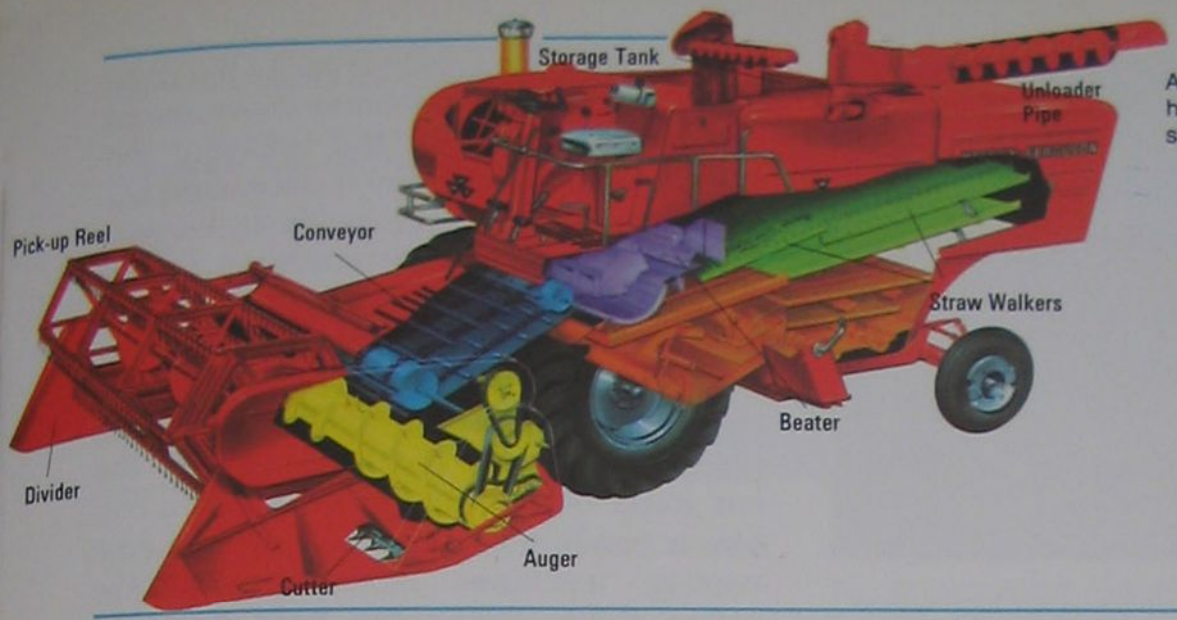
Many farmers grow more than one kind of crop, but some depend on one crop if the soil and climate are very suitable. Growing different crops on the same land from year to year is called *rotation of crops*, and is very good for the land.

Raising livestock is the other main branch of farming. Cattle, pigs, sheep and goats, as well as poultry, are all raised to provide food. On ranches, cattle are kept for their meat, but on dairy farms they are kept to produce milk. Cattle hides and the skins of pigs, sheep, and goats are used to make leather. Sheep and goats are also kept for their wool and hair. Farmers keep other animals such as horses and mules as beasts of burden.

Farming is the second oldest occupation known to mankind. Its discovery was a turning point for the human race, for it meant that Man became a food producer. Previously he was a food gatherer (hunting for meat and picking wild berries) just like the other animals. The first farming communities probably grew up around the great rivers such as the Nile in Egypt and the Ganges in India. Prehistoric farming tools like the spade and the hoe that date back to 7000 B.C. have been found in these areas. The invention of the plough enabled much greater areas of land to be cultivated. There is evidence that it was in use in Asia before 2000 B.C. The plough is a blade that cuts into the earth at an angle and turns it over, making it ready for sowing. The first ploughs were drawn by people and in some parts of the world this method is still practised today. Man started to keep and breed domestic animals like cattle and sheep at an even earlier stage in his development. He lived the life of a nomadic herdsman, driving his animals on to fresh pastures whenever they had eaten all the food in one place.

Over the centuries, Man's farming methods improved. He cut down areas of forest to provide more land for cultivation. He used horses or oxen to draw the plough instead of doing it himself. The ancient Greeks and Romans dug wells and built aqueducts (stone channels raised above the ground) to bring water to dry, infertile places and make them fit for growing crops. They also drained the water from marshes and swamps to increase the amount of farming land. The advantages of fertilizing the land with animal manure were discovered at an early stage. Crop rotation has been practised in Europe since the Middle Ages.

Farming developed very gradually, and until the 1800's, when mechanical farm machinery driven by steam was introduced, people used tools similar to those



A self-propelled combine harvester cut away to show its construction

in use in prehistoric times. During this century, the application of scientific techniques to farming has reduced the farmer's labour and increased his reward.

In raising crops and fruit, fertilizers have improved yields vastly. The fertilizers add chemicals to the soil that are otherwise missing, and help the plants to grow. Crop rotation also prevents the soil from losing vital minerals, and terracing the land or planting trees helps to prevent erosion of the soil. Irrigation has brought water to arid areas, and life to dry soil. The use of insecticides has removed insect pests from the land, and vaccination has prevented animals from succumbing to disease. In both crop farming and animal farming, breeding healthier and more productive strains has increased yields (see Breeding).

Talking points

*Farms in Europe tend to produce far more food per acre than farms in Australia, America and Canada. Why do they do this? Try to discover some of the methods that they use to produce higher yields.

*The rotation of crops is an important feature of modern farming. What is the reason for doing it?

*In the developing countries of the world, farming is often still done by traditional, primitive methods. Discuss the ways in which the richer countries could help to improve this situation. Remember education. For what reasons should they do this?

Articles to read

Cattle; Dairy Farming; Fertilizers; Farm Machinery; Food; Fruitgrowing; Pigs; Rice; Sheep; Wheat.

Farm machinery is an indispensable aid for the farmer and helps him to produce more crops or animals. The number of people employed in farming has declined over the past 100 years, but their productivity has soared, reflecting the value of scientific techniques in farming and the use of machinery.

The main item of machinery used on the farm is the tractor, which is used to

Below: A combine harvester cuts grain crops, threshes them to remove the grain, and jettisons the straw. Bottom: A harrow rakes the ground before sowing.

Above: A tractor, the modern replacement for the horse and ox in developed countries, pulls all kinds of implements. Here it is attached to a manure spreader. Below: A plough, pulled by a tractor, breaks up the soil before planting.

pull many kinds of implements over the land—to prepare it for seeds, to plant the seeds, and to help cultivate and harvest the crops. The tractor has replaced the horse and ox in all developed countries.

Ploughs and harrows are pulled by tractors to break up the soil in readiness for planting. Seed drills place the seeds in rows in the soil, usually adding some fertilizer to help the crops grow. Some planting machines spray out seeds, such as grass seeds, over a wide area. As the crops grow, mechanical cultivators move among them, killing weeds and applying fertilizers and insecticides if necessary.

When the crops are ready to harvest, a great variety of farm machines can be used to gather them safely in. The combine harvester is a complex machine that gathers wheat and similar crops. It cuts the wheat, threshes it (removes the grain), places it in bags, and then deposits the cut stalks back on the ground. When cotton is ready for harvesting, rows of harvesting machines move through the cotton fields taking the bolls from the plants.

Machines can even be used to pick fruit. The machine is situated under the tree, which it shakes thoroughly, and the fruit drops into a catching frame. A potato harvester can be used to dig up potatoes from the ground.

Farm machinery is also used to help raise livestock. Many cows are milked by electric milking machines, and cattle, poultry and other animals may be fed by grinding their food into a form that can be delivered mechanically by conveyors to the animals. Many farmers find that they can improve their productivity by raising their livestock indoors. The animals are kept in small pens, maintained in warm conditions, and fed and watered regularly. But some believe that this kind of farming produces meat and other food of low quality.

Faroes are a group of volcanic islands in the North Atlantic Ocean, situated about halfway between Scotland and Iceland and with an area of 540 square miles. The islands belong to Denmark, but are self-governing in many matters. Seventeen of the islands are inhabited. The largest is Strömö, on which the capital, Thorshavn, is located.

About 38,000 people live in the Faroes, of whom most are descended from Norse settlers. They raise sheep for wool, but farming is difficult because the land is

Guy Fawkes and his conspirators in the Gunpowder Plot. This illustration comes from the title page of a book published in 1606, the year after the event.

barren. Fishing is also an important means of livelihood.

Fascism was a political belief founded by Benito Mussolini. He seized power in Italy in 1922 and set up a dictatorship. His critics were imprisoned or murdered, trade unions were taken over by the state, and all political parties except the Fascists were closed down. Fascists were organized like soldiers, with uniforms, drill and training in using weapons. Similar training was given to women and even small boys. At first many Italians supported Mussolini, because he ended strikes and reduced unemployment by building roads and draining marshes. In 1936 he defeated Ethiopia, an ancient African state, and made it part of his 'new Roman Empire'. His later wars, as Hitler's ally, were not so successful. In 1943, during the Second World War, when the allied armies invaded Sicily, Mussolini's own supporters drove him out. He was executed by Italian partisans in 1945.

Fawkes, Guy (1570-1606), was one of a group of Roman Catholics who conspired to blow up King James I and the House of Lords on November 5, 1605. When James came to the throne in 1603, he announced a number of laws aimed at controlling Roman Catholics. A plot was hatched to stop the king's plans to pass the laws. But the conspiracy, which became known as the *Gunpowder Plot*, failed. November 5 is now remembered as Guy Fawkes Day, because it was Guy Fawkes who was caught in a cellar full of gunpowder beneath the House of Lords. On this day each year people in England burn a dummy figure, called a 'guy', and let off fireworks.

Guy Fawkes was born in York, and became a Roman Catholic. In 1593 he joined the Spanish army in Flanders. Robert Catesby, a leading Roman Catholic, invited Guy Fawkes to return to England. They tried to enlist the help of the Spaniards in persuading King James to change his attitude towards Roman Catholics. This failed, and Catesby and some friends decided on what became known as the Gunpowder Plot. They rented a house which adjoined a cellar right under the parliament, and filled it with gunpowder. But the plot was discovered in time. Guy Fawkes was caught in the cellar and taken prisoner. The other conspirators were also caught, and all of them were executed.

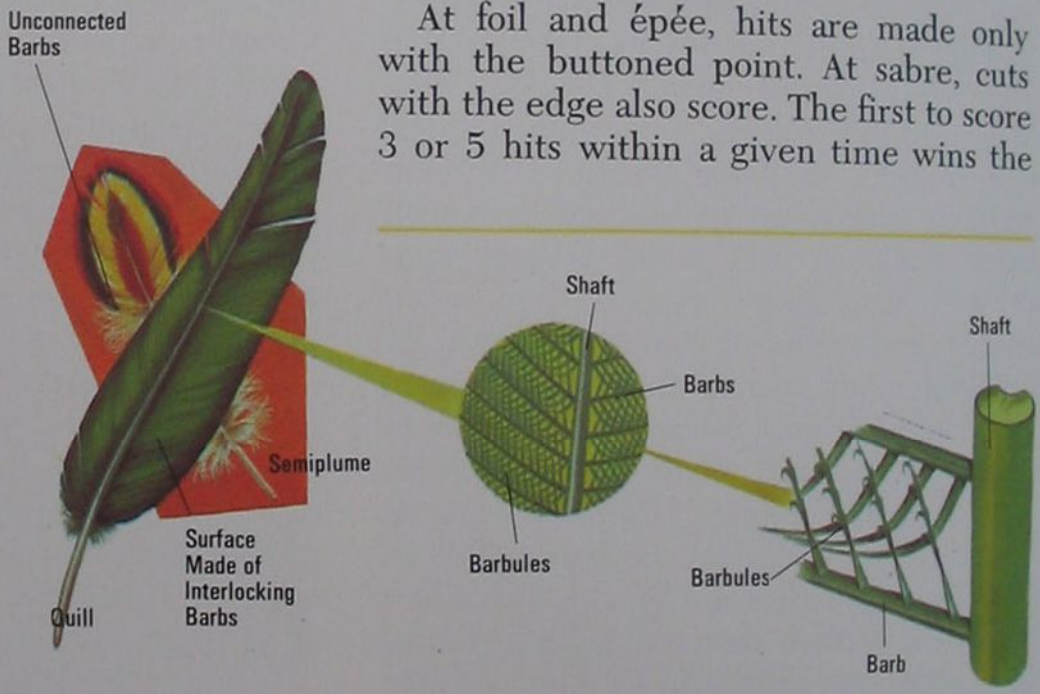
Feathers form the characteristic outer covering of birds. They enable birds to fly, by forming the correct wing shapes and by giving their bodies a smooth, streamlined surface. They also keep birds warm, by trapping a layer of air next to their bodies.

Many birds have coloured feathers, some of them very bright. These are important for protective camouflage and for courtship displays at times of mating. In many birds, the male has much brighter colouring than the female.

Feathers are made of a horny substance

Young chicks are covered with fluffy down (below). These feathers help to keep the chick's body insulated from cold. They trap a layer of air against the skin, preventing heat escaping from the body. In adult birds, the down feathers are usually not conspicuous as they are covered by contour feathers.

Contour feathers are light with a large surface area made of interlocking barbs. Semiplume feathers develop with some barbs unconnected (left). The barbs are so closely packed together that they appear to form a continuous surface. They are, in fact, separate, though each one is connected to its neighbours by a series of hooked and notched barbules (centre). A magnified view of the barbules (right) shows how the hooked barbules on the top surface of each barb interlock with notched barbules suspended from the bottom surface.



called *keratin*. The two most important kinds of feathers are the leaf-shaped *contour feathers* and the fluffy *down feathers*. Contour feathers are large and cover the body of the bird as well as the wings and tail. The central stem extends the whole length of the feather. The part that remains embedded in the bird's skin is called the *quill*. It is usually hollow.

The rest of the contour feather above the skin's surface is called the *vane* or *web*. It consists of the central shaft and a large number of small branches called *barbs* coming off from either side.

Down feathers are much smaller and the shaft does not extend above the skin. The soft branches all extend from the short quill. The fluffy coats of young chicks are made up entirely of down feathers. On adult birds, they lie close to the skin, covered by contour feathers.

Fencing Modern fencing is practised with three weapons: the *foil* (seventeenth-century French in origin), the *épée* (nineteenth-century French) and the *sabre* (nineteenth-century Italian). Fencers wear protective clothing consisting of canvas jacket and breeches, a special glove on the sword hand, and a mask. Weapons are blunted.

At foil and épée, hits are made only with the buttoned point. At sabre, cuts with the edge also score. The first to score 3 or 5 hits within a given time wins the bout. Foil and épée are now judged with the aid of electrical apparatus to record hits.

The target for foil is restricted to the trunk only, while the sabre target includes head and arms. With these two weapons strict rules and conventions are observed to avoid simultaneous actions. Priority is given to attack until it is parried, when it passes to the defender for his riposte, and so on through a sequence of movements.

Épée fencing is based on duelling.

Hits may be made on any part of the body, limbs or head, and are judged entirely on a time basis, the object being to hit one's opponent first avoiding, if possible, being hit oneself.

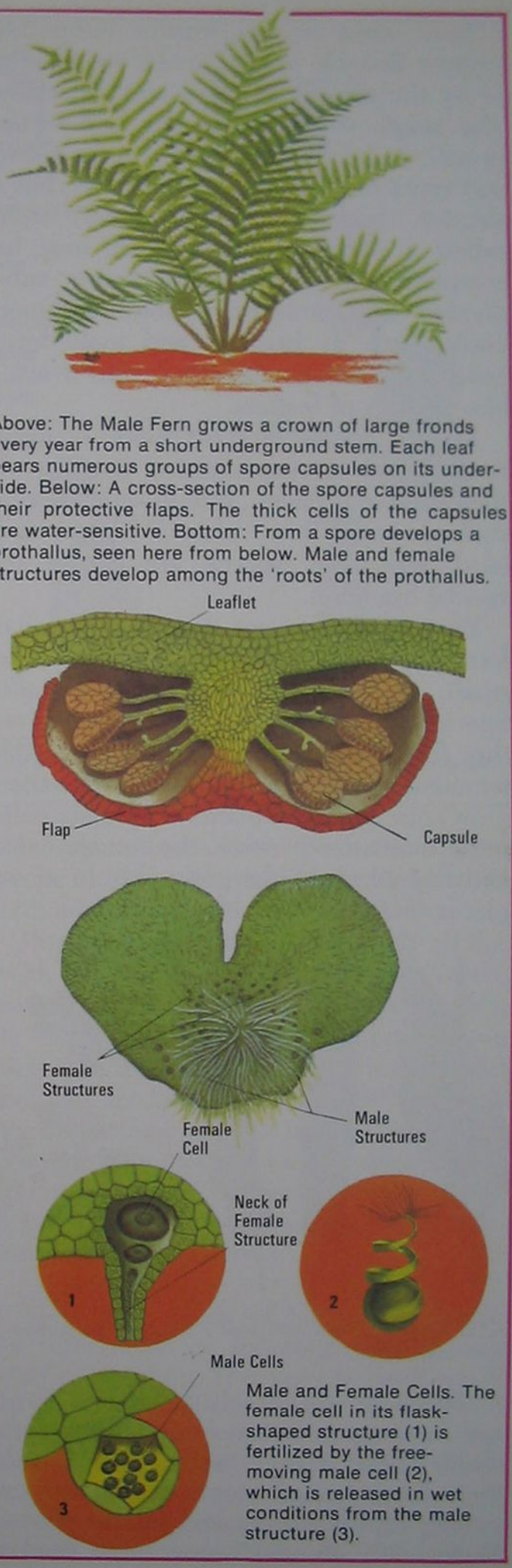
Fencing, the skilled use of a sword, has been practised since before the dawn of recorded history. It is known as an Egyptian sport in the 12th century B.C. Its importance as a universal sport grew in the mid-nineteenth century with the prohibition of duelling. World Championships have been held since 1921, and fencing has been included in the Olympic Games since 1896.

Fermi, Enrico (1901-1954), an Italian-born nuclear physicist, experimented on the bombardment of atomic nuclei with neutrons. He found that slow neutrons produced a greater reaction. He created the artificial radioactive element neptunium from uranium, and was the first to accomplish *atomic fission* (splitting the atom), though he did not realize what he had done.

In 1938, Fermi received the Nobel Prize for physics, and moved to the United States to avoid Italy's Fascist government. In 1942, he produced the first controlled chain reaction of uranium 235. This was a major step in the development of the atomic bomb, a project on which he worked.

Fermi was a professor of theoretical physics at the University of Rome from 1926 to 1938. In the United States, he taught at Columbia University and, later, at the University of Chicago.

Ferns are a large group of plants that have a root, stem and leaves like flowering plants, but which reproduce with spores and not with seeds. They have no flowers. Botanists know of about 10,000 kinds of ferns. Most of them grow in damp, shady places, but only two kinds actually grow in water. They vary greatly in size from tiny, free-floating water forms to huge tree-ferns of 60 feet or more.



Above: The Male Fern grows a crown of large fronds every year from a short underground stem. Each leaf bears numerous groups of spore capsules on its underside. Below: A cross-section of the spore capsules and their protective flaps. The thick cells of the capsules are water-sensitive. Bottom: From a spore develops a prothallus, seen here from below. Male and female structures develop among the 'roots' of the prothallus.

Male and Female Cells. The female cell in its flask-shaped structure (1) is fertilized by the free-moving male cell (2), which is released in wet conditions from the male structure (3).

Most ferns of the world's temperate regions flourish in cool, moist woodlands, or by the sides of streams and waterfalls. The small, stubby stem lies half-buried in soil, and from it emerge leaves above and roots below. Bracken, however, has a slender, branching, underground stem called a *rhizome*. Fern leaves may be complete and undivided *(entire)* or subdivided in various ways. Some common kinds, such as bracken and male fern, have their fronds dissected into a lace-like pattern of leaflets.

Mature leaves of most kinds of ferns bear spores in rust-coloured patches on their under-surfaces. But in some ferns, such as royal fern, adder's tongue and hard fern, the spores are borne on special branches.

Fern spores do not grow into familiar fern plants. Instead, they develop into small, green structures called *prothalli*. Special male and female cells develop on the prothallus. Male cells fertilize the female cells and the fertilized cells then grow into new fern plants. The male cells need moisture to reach the female cells, and that is why ferns grow only in moist places.

Adder's Tongue Fern (left); Hart's Tongue Fern (centre); Wall Rue (right).

Horsetails are closely related to ferns and have many features in common with them. These strange looking plants, with their bare, jointed stems often grow on railway embankments and in wet places. Today, only about 25 kinds exist from a once colossal group. Huge horsetails, as much as 100 feet tall, grew in swamps many millions of years ago. Their remains went to make the coal we use today (see Coal).

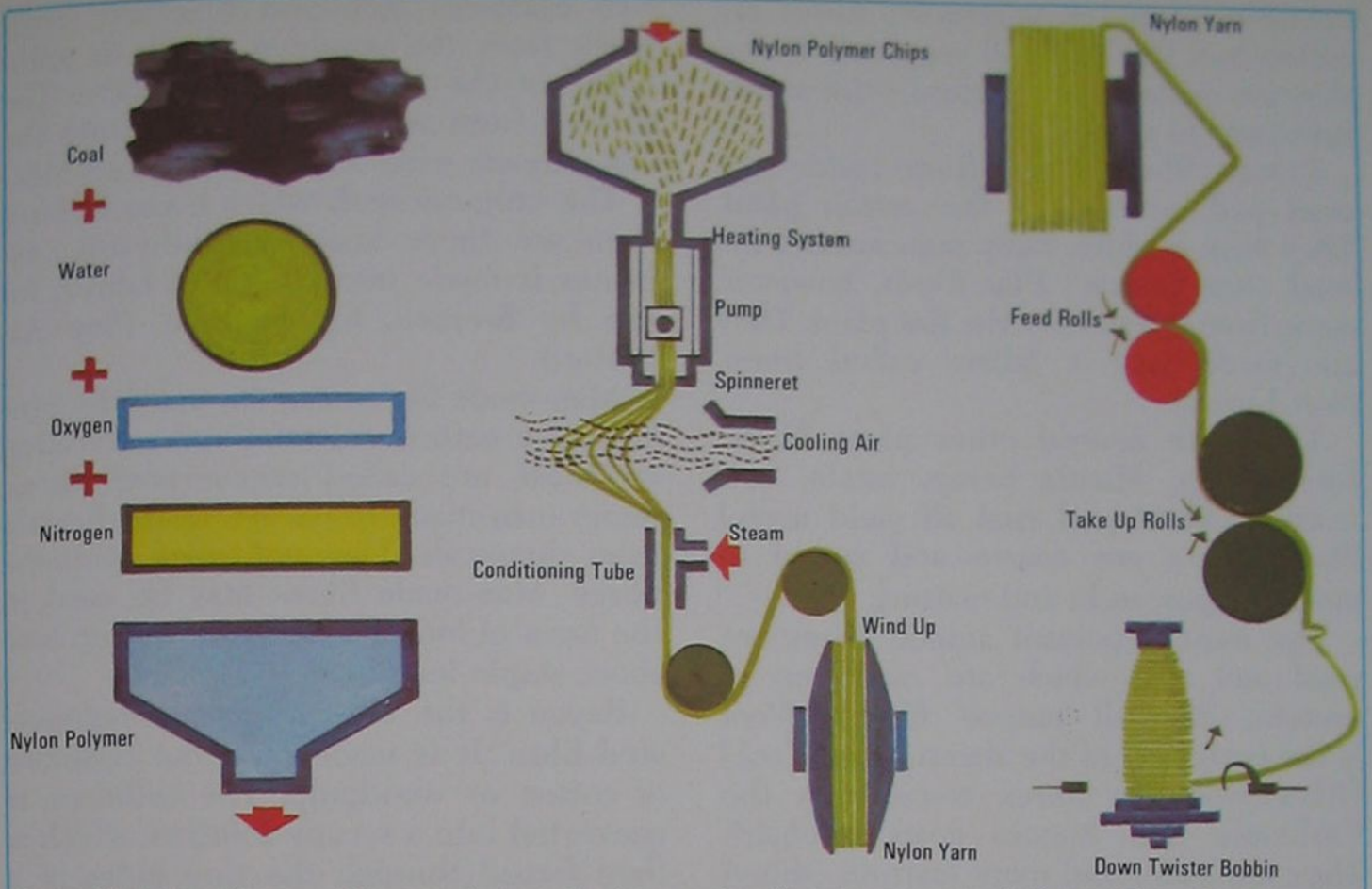
Fertilizers are substances that are put into the soil to aid the growth of plants. All plants need certain elements to grow. If these elements are missing from the soil, then they must be added to it by digging in fertilizers.

The main essential elements to come from the soil are calcium, nitrogen, phosphorus, potassium and sulphur. A plant obtains three other essential elements – carbon, hydrogen and oxygen – from the air and water. But the first five elements must be present in the soil so that rainwater dissolves them as it percolates through the soil. When the plant takes up the rainwater through its roots, it takes up the elements too.

Calcium is added to the soil in the form of wood ash or lime. Nitrogen is added in the form of saltpetre (potassium nitrate) and other nitrates, and as ammonium sulphate, which is made artificially. Nitrogen is also given to the soil by digging in manure or *compost* (rotting plants). Phosphorus occurs in rocks as phosphates, but phosphate fertilizers are usually made artificially. Potassium also occurs in saltpetre, and sulphur is another useful element in ammonium sulphate.

Feudal system Life was not safe in the Dark Ages, when warring bands roved over most of Europe, and might meant right. Chieftains and princes wanted armed, mounted soldiers to fight their rivals, while poor men needed a powerful lord to protect them. The arrangements made to meet these needs formed what we call the Feudal system.

Kings granted land to 'tenants-in-chief' in return for various services. The tenant swore 'homage and fealty' to his lord, and became his 'man' (vassal). The land granted was known as a 'fee', and



A simplified flow diagram of the manufacture of nylon, the best-known synthetic fibre. The manufacture of the polymer (left) is a complex process based on coal (or oil), water, oxygen and nitrogen. The polymer is heated and extruded into yarn (centre). The yarn is then cold-drawn, or stretched, to make fibres (right).

this word is the source of 'feudal'. The chief services provided for a lord were: a fixed number of knights when needed for war; aids on special occasions when the lord needed money; and advice. The three feudal aids were for knighting the lord's eldest son; the marriage of the lord's eldest daughter; and ransoming the lord's body if he were taken prisoner.

In order to supply the knights, the vassal granted some of the land to men who would perform this service for him. Such lands was called a 'Knight's Fee'. The knight in his turn swore homage and fealty to his lord.

All the services needed could be got by granting land. The free peasant paid a cash rent for his. Agricultural work was done by the unfree peasant (villein) in return for his land. The villein belonged to his lord and could not leave him. But the lord was expected to protect him.

In this way all men, from king to humblest peasant had a place with their own rights and duties. Each was bound to be loyal, although if a lord broke faith his man could withdraw fealty.

Important lords often did nearly all the work of government on their own lands. So a large estate, with its army of knights, its counts, and its council, often became like a miniature state. Its lord might feel and act like a local king. When kings became strong enough to take away such powers from any of their subjects, and when full-time soldiers proved much better than the part-time knights, feudalism began to fade away.

Fibres Most kinds of fabrics are made by interlacing, or *weaving*, yarn of one kind or another. The yarn is itself made up of short fibres which have been twisted together, or *spun*, into a continuous thread (see Textiles). These fibres may be natural or man-made.

Natural fibres come from certain plants, animals, and even minerals. The most

common plant, or vegetable, fibres are cotton and flax. Like all vegetable fibres, they are made up of cellulose – the woody substance in plants.

Cotton fibres come from inside the seed pod, or *boll*, of the cotton plant. They form a white, fluffy mass around the seed. (See Cotton.) Flax fibres, however, come from the stem of the flax plant. They are made into a fabric called linen. (See Linen.)

There are several other plant fibres. Jute, hemp, Manila hemp, ramie, coir (coconut fibre) and sisal all yield useful fibres. They are coarse and suited to making ropes, sacks and matting.

The most important animal fibres are wool and silk, which are made up of protein, like all animal fibres. Wool is the curly hair of the sheep. (See Wool.) Other wool-like fibres come from the Cashmere and Angora goats (mohair). They are softer and more lustrous (shiny) than wool. The hair of camels is also used to make cloth.

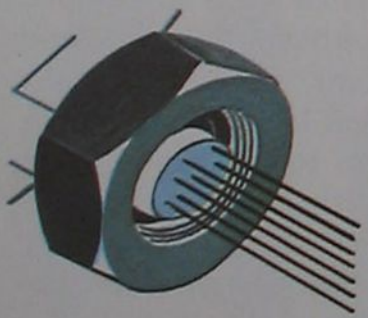
Silk is a fine, lustrous thread obtained from the cocoon spun around itself by the silkworm, which feeds on mulberry leaves. The thread is actually made up of two filaments gummed together. They come from the spinning gland, or *spinneret*, in the head of the silkworm. The threads from several cocoons go into the silk threads used for weaving. (See Silk.)

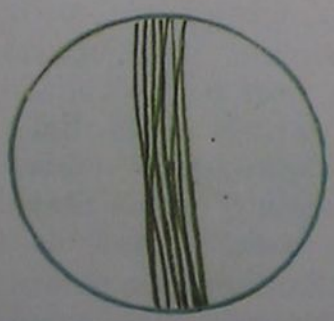
The only minerals which occur in fibre form are those known as asbestos. Asbestos is made into heatproof fabrics for use by firemen, for example. (See Asbestos.)

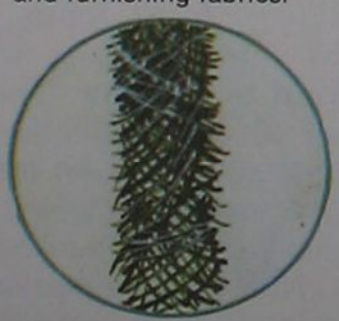
Man-made fibres may be made by processing a natural material and re-forming it. These are called *regenerated* fibres. Some man-made fibres are made directly from chemicals. They are called *synthetic* fibres. Man-made fibres may be used in the form of long filaments, or cut up into short, staple lengths.

Rayon is the most important regenerated fibre. It is made from the cellulose of cotton or woodpulp. The cellulose is converted into a syrupy solution, which is then forced through the tiny holes of a spinneret to form continuous filaments. The cellulose in the filaments is then regenerated to form the fibre. (See Rayon.)

Synthetic fibres are made from *polymers*, which are chemical substances with long chain-like molecules. The molten polymer is forced through a spinneret into filaments which dry and harden. They are collected into a thread and *cold-drawn*, or stretched, to make fibres. This process is called *melt spinning*. Nylon is the best-known synthetic fibre; it is made from polymers called *polyamides*. (See Nylon.) Terylene, Dacron and Fortrel are polyester fibres. Acrilan, Dynel and Orlon are acrylic fibres.







Left: A spinneret may contain as many as 10,000 tiny holes. Below left: A spinneret produces *continuous filament* yarn (shown greatly magnified). This yarn is used for smooth fabrics. Below: The continuous filaments may be cut into short pieces, producing *staple* yarn (shown greatly magnified). This yarn is used to make fuller materials suitable for blankets and furnishing fabrics.

Talking points

* Look at the clothes that you are wearing and find out the fibres that they are made of. Make a list of them and say whether these fibres are of animal, vegetable, or man-made origin. If you are in doubt about the fibre, look at the label.
* When wool is on a sheep's back, it is in short strands. How many different processes does it have to go through before it ends up as a sweater on your back?
* Nylon and other synthetic fibres are becoming more common. Discuss what advantages and disadvantages they have compared with natural fibres. Which do you prefer wearing and why?

Articles to read

Asbestos; Cellulose; Cotton; Plastics; Rayon; Silk; Spinning and weaving; Textiles; Wool.